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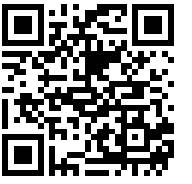

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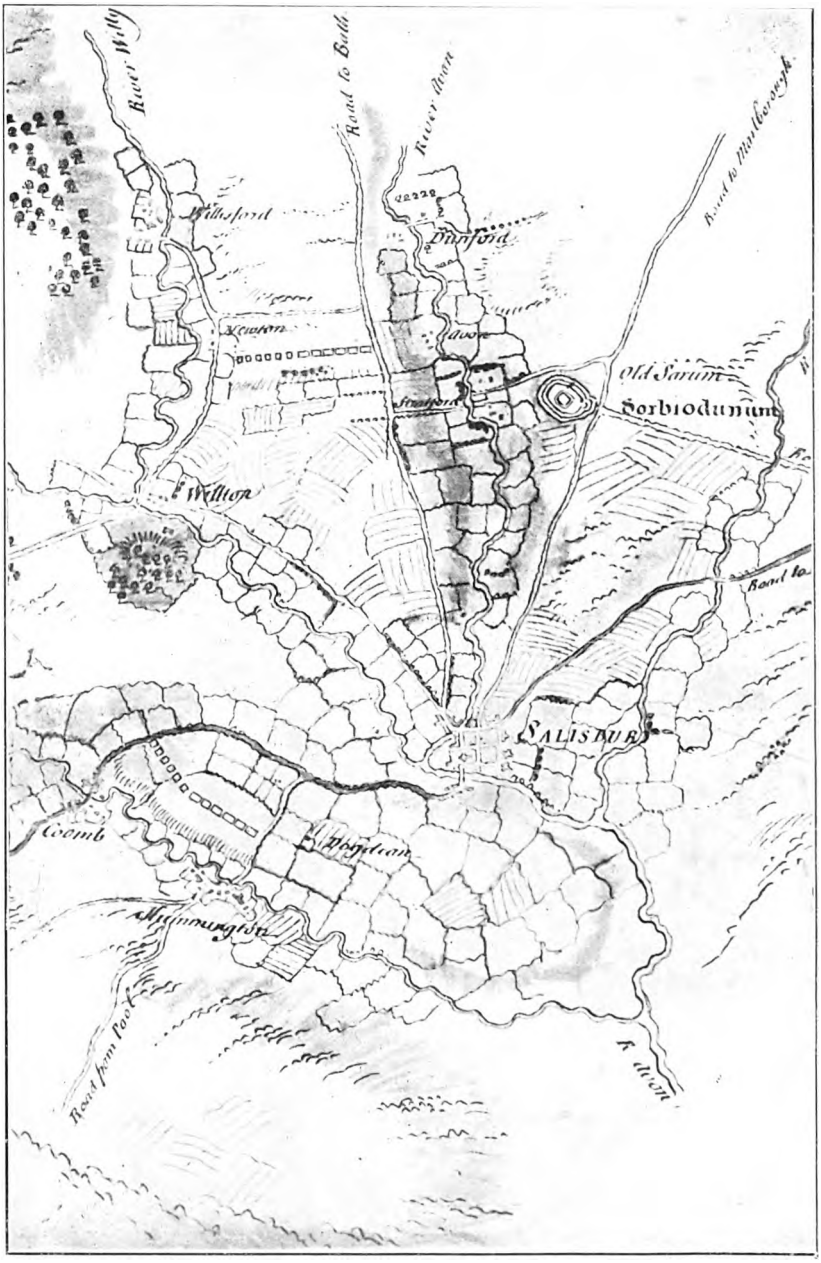
# NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.




**Portion of a Road Survey from Salisbury to Dorchester by Lieut. W. Roy. June, 1756. Scale 1″ to 1 mile.**

"Reconnoitred by Colonel D. Watson, Q.M.G. of H.M. Forces."

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# *NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.*

## With some Account of its Founders.

*By* Colonel Sir Charles F. Close, K.B.E., C.B., C.M.G., F.R.S.

### Introduction.

**The Sources of Information.**—The period covered by these notes is the hundred years between 1746 and 1846. The Ordnance Survey did not formally exist during the whole of this period; but it is necessary, in order to show how it came into existence, to commence at the date first mentioned. The writer of these notes has been fortunate enough to be entrusted with the custody of a considerable number of letters and documents, hitherto unpublished, covering a large part of the period. The letters and documents were—in the main—collected by Major-General Thomas Colby,* F.R.S., who was Director of the Survey from 1820 to 1846. The writer is much indebted to Miss A. Colby and Miss C. Colby, the daughters of General Colby, for permission to make use of this collection, which includes some original letters written by General William Roy, who may justly be called the founder of the Survey.

Amongst other sources of information should be mentioned a book entitled *The Memoirs of the Mudge Family*, which contains an account of the life of General Mudge, F.R.S., who was Director of the Survey from 1798 to 1820. There is also a valuable addition to the literature of the subject in Mr. George Macdonald's *General William Roy and his Military Antiquities of the Romans in North Britain*, which was published by the Society of Antiquaries in 1917. And there are some old letter-books preserved in the Ordnance Survey Office at Southampton which occasionally throw some light on the early history of the Survey.

Of the sources of information that have already been used in the two little books on the Survey by Capt. H. S. Palmer (1873), and Lieut.-Colonel T. P. White (1886), it is only necessary to mention the various volumes of the *Philosophical Transactions* of the Royal Society; the *Memoir of the late Major-General Colby* by Lieut.-Colonel Portlock, F.R.S., printed in the *R.E. Professional Papers* for 1853–55–56, and the various technical publications of the Survey, ending,

* Pronounced *Cole-by*.

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for this purpose, with Clarke's celebrated *Account of the Principal Triangulation*, (1858). The lives of Roy, Colby and Ramsden in the *Dictionary of National Biography* should also be mentioned.

## I. ROY AND HIS TIMES.

**The Forty-five.**—About the middle of the eighteenth century the fortunes of this country were, for a time, in the hands of two young men—Charles Edward, the Young Pretender, grandson of James II.; and the Duke of Cumberland, son of George II. It is an old story how Charles Edward raised the standard of his father in August, 1745, how he and his troops occupied Edinburgh and Carlisle and marched as far south as Derby, were compelled to retreat, and were finally defeated by the Duke of Cumberland, at Culloden, on a misty, drizzly day in April, '46.

**The Map of the Highlands.**—It is not known what maps were used in this campaign by the Duke of Cumberland and his staff, but it is certain that they were very imperfect and that the Deputy Quarter-Master-General, Lieut.-General Watson, experienced the need for better ones. There were, in fact, no reliable maps available for the use of the Army, either in the operations which terminated in Culloden, or during the subsequent pacification of the country. General Watson therefore determined to make a map of the Highlands and it is from the commencement of this mapping of the Highlands, in 1747, that we should, perhaps, date the first idea of an Ordnance Survey, for the work was carried out, under the orders of the Government, by the Army. We have an authoritative account of the circumstances which gave rise to this undertaking, written by William Roy, and published in the *Philosophical Transactions* of the Royal Society for 1785. The interest of the matter may, perhaps, justify a lengthy extract. Roy says:

"The rise and progress of the rebellion which broke out in the Highlands of Scotland in 1745, and which was finally suppressed by His Royal Highness the Duke of Cumberland at the battle of Culloden in the following year, convinced Government of what infinite importance it would be to the State that a country, so very inaccessible by nature, should be thoroughly explored and laid open, by establishing military posts in its inmost recesses, and carrying roads of communication to its remotest parts. With a view to the commencement of arrangements of this sort, a body of infantry was encamped at Fort Augustus in 1747, under the command of the late Lord Blakeney, at that time a Major-General; at which camp my much-respected friend, the late Lieut.-General Watson, then Deputy Quarter-Master General in North Britain, was officially employed. This officer, being himself an Engineer, active and indefatigable, a zealous promoter of every useful undertaking, and the warm and steady friend of the industrious, first conceived the idea of making a map of the Highlands. As Assistant Quarter-Master, it

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fell to my lot to begin, and afterwards to have a considerable share in, the execution of that map; which being undertaken under the auspices of the Duke of Cumberland, and meant at first to be confined to the Highlands only, was nevertheless at last extended to the Lowlands; and thus made general in what related to the mainland of Scotland, the islands (excepting some lesser ones near the coast) not having been surveyed.

"Although this work, which is still in manuscript, and in an unfinished state, possessed considerable merit, and perfectly answered the purpose for which it was originally intended; yet having been carried out with instruments of the common, or even inferior kind, and the sum allowed for it being inadequate to the execution of so great a design in the best manner, it is rather to be considered as a magnificent military sketch, than a very accurate map of a country. It would, however, have been completed, and many of its imperfections no doubt remedied; but the breaking out of the war of 1755 prevented both, by furnishing service of other kind for those who had been employed upon it."

The original field sheets of this map are preserved in the King's Library in the British Museum, so far as concerns the greater part of Scotland, namely, that part which is north of the Forth and Clyde. There are a few scattered sheets south of this line. This "original protraction" covers 84 rolls of very varying sizes. The right and left edges of the sheets run roughly parallel to the magnetic north and south of the date of the work, that is, about 17° W. of true north.

The work is clearly an elaborate compass sketch; the roads and some of the streams have been paced, and the mountains have been put in roughly by eye. Near the towns the work is carefully drawn. Cultivation is indicated by open diagonal hatching. The hill-features are shown by rough, faint, brush, sepia shading or *hachuring*; the larger mountains are shown by similar, only darker, shading.

No sheet is dated and no sheet is signed. And this is a pity, because some very interesting men were employed on the work, in addition to Roy; for instance, David Dundas, afterwards Commander-in-Chief; and Paul Sandby, the artist, who was afterwards an instructor at the R.M. Academy.

The British Museum also holds the "fair protraction" of the map, on the same scale and in the same style, but complete for the whole of Scotland except the islands. These fair drawings are folded in 38 sections, numbered systematically from south to north.

The scale of the map is apparently intended to be 1,000 yards to one inch, or 1 : 36,000, a scale which was never again adopted for official maps in this country. This scale lies between the 6-inch and the 1-inch scale, and it is possible that if it had been revived we should have used it in substitution for these scales. A map on the 1,000-yards scale covers about three times the area of ground

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that a 6-inch map covers on a piece of paper of the same size, and shows very nearly as much detail. The map was never printed, but a reduction on a single sheet was made by Roy before the spring of 1774, when it was engraved, and ultimately published in the *Military Antiquities*. Mr. Macdonald quotes an extract from Roy's will, which is dated 13th November, 1786 :—

" I request that Colonel Dundas will take the pleasure of a most gracious Sovereign with regard to the manuscript map of Scotland remaining in my custody, he having been employed in the execution of that map." The complete large manuscript map and the rolls of the " original protraction " thus passed to the King's Library and thence to the British Museum—a very appropriate resting-place for them.

**William Roy.**—William Roy was born at Milton Head in Carluke parish, Lanarkshire, on the 4th May, 1726. He was educated at Carluke parish school and afterwards at Lanark. He appears to have held a minor position in the post office at Edinburgh until 1747.

In that year he states that he served as Assistant Quarter-Master under Lieut.-General Watson, then Deputy Quarter-Master-General in North Britain. He was never in the Artillery, as is sometimes stated, and it is not certain that he held any military rank in 1747. He was certainly not Assistant Quarter-Master-General in that year, as stated by Portlock.

Towards the end of the *Colby Memoir* Portlock gives a list of Roy's appointments in the Engineers. His name appears as Practitioner Engineer in the *Army List* of 1756, and he had been so appointed on the 23rd December, 1755. He received a commission in the 53rd Foot on the 4th January, 1756. He became Practitioner Engineer and Ensign of the New Corps of Engineers on May 14th, 1757 ; Sub-Engineer and Lieutenant, 1759 ; Captain in the same year ; Director and Lieut.-Colonel of Engineers, 1783 ; Colonel, 1785. In the Army his various ranks were always senior to those he held in the Corps. Thus—he was Lieut.-Colonel in the Army in 1762, Colonel in 1777, Major-General in 1781.

He was D.A.G. in 1764–65, D.Q.M.G. in 1766 and was appointed Colonel of the 30th Foot in 1786.

We may, perhaps, agree with Mr. Macdonald, when he says that during the construction of the map of Scotland, which was in progress from 1747 to 1755, Roy was not in the Army at all ; although the map was a military undertaking and Watson employed soldiers on the work. But if Roy was not formally in the Army when he was Assistant Quarter-Master, he worked with soldiers, and was closely identified with the Army, and shortly after the outbreak of the Seven Years' War, when he was not quite 30 years old, he received a commission, as stated above.

Roy was evidently recognized as a capable man, for in 1756 he

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was employed in making reconnaissances and plans in Great Britain ; in June, 1756, for instance, we find him employed in drawing a reconnaissance map, on the 1-inch scale, of the strip of country between Salisbury and Dorchester. In 1757 he took part in the expedition against Rochefort and later was present at the battle of Minden. He was D.Q.M.G. in Germany in 1760–61 ; then D.Q.M.G. to the Forces in South Britain ; then in 1762 D.Q.M.G. in Germany. Then came the peace of 1763.

On 31st July, 1765, Roy was appointed, by Royal Warrant, Surveyor-General of Coasts and Engineer for making and directing Military Surveys in Great Britain, in addition to his appointment as D.Q.M.G. The wording of the warrant is that he was appointed " to inspect, survey and make Reports from time to time of the state of the Coasts and Districts of the Country adjacent to the Coasts of this Kingdom and the Islands thereunto belonging " ; this is addressed to the Master-General of the Ordnance, who is to pay Roy an allowance of twenty shillings a day for these duties. The payment continued until Roy's death.*

Although the " Surveys " referred to in the warrant probably implied no more than inspections and investigations, still, Roy did, as a fact, from this time until his death, except for the period of the American War, occupy himself with map-making whenever the occasion permitted, and did not cease to advocate the formal establishment of a National Survey.

The outline of his subsequent career is briefly :—In 1767 he was elected a Fellow of the Royal Society ; in 1768 he visited Gibraltar and reported on the defences ; in 1783 he was a member of the Committee on the defence of Chatham, and was appointed a member of the board on Fortifications presided over by the Duke of Richmond, Master-General of the Ordnance ; in 1778 he read a paper before the Royal Society on *Rules for Measuring Heights with a Barometer* ; in 1783 he commenced the triangulation between London and Dover, and in 1784 he undertook the measurement of the base on Hounslow Heath. He was, in 1785, awarded the Copley medal of the Royal Society for this work.

In 1787 he read a paper before that Society on *The Relative Situation of the Royal Observatories of Greenwich and Paris.* On 23rd September, 1787, he met the French Commissioners at Dover ; in 1789 his health began to fail and he went to Lisbon for the winter. He died suddenly in his house in Argyll Street, London, in July, 1790, whilst he was correcting the proof sheets of his paper for the Royal Society, entitled *An Account of*

* See *General William Roy and his Military Antiquities of the Romans in North Britain.* George Macdonald Esq., C.B., F.S.A., LL.D., Oxford. Printed for the Society of Antiquaries, London.

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*the Trigonometrical Operations by which the Distance between the Meridians of the Royal Observatories of Greenwich and Paris has been Determined.* The manuscript of his great work, *The Military Antiquities of the Romans in North Britain*, was left ready for printing. The Society of Antiquaries published this, in 1793, in a splendid folio.

**Roy's Letters from the Colby Collection.**—The earliest letter in this collection is dated 1771. On the 26th October, 1771, Roy, writing probably to Dr. James Lind, says:—

DEAR SIR,

I fear from the unfavourableness of the weather, or some other cause, our operations on Calton hill on Thursday last are not what they ought to have been.—I don't know whether you have already made any calculations from them. Mine were done in a very great hurry and therefore I may have committed some mistake. However, you will no doubt observe, that in the triangle comprehended between the Observatory, Arthur Seat and the Calton hill, all of whose angles were taken, the sum exceeds by some five minutes and some seconds, 180 degrees. . . . The angle taken with my Quadrant on the Calton hill, comprehended between Arthur Seat and Kirk Newtown I found to be 113° 35′ 23″ . . . if an error so great is really made there it must have arisen from some motion in the Quadrant . . . from having only one Telescope. . . .

I am just going over to Sir Wm. Erskine's in Fife. I mean to return on Monday evening and before I go south will have the pleasure of seeing you. In the meantime I am with great regard,

Dear Sir,

Your most obedt. humble servant,

W. ROY.

It is not quite certain what kind of a quadrant was used by Roy, but the fact that he used one is interesting. It will be noted that he states that the instrument had only one telescope. The writer has consulted Mr. R. T. Gunther on the subject. Mr. Gunther is a high authority on old instruments, and his book on *Early Science in Oxford* may be studied with profit by all who are interested in such matters. In Rees' *Encyclopædia* of 1789, a surveyor's quadrant is described; this consisted of a quadrantal board with fixed slot-sights along one margin, and a movable radial alidade, also with slotted sights. The instrument was fixed in the horizontal plane by a ball-and-socket joint on a tripod. There was a diagonal scale for reading by. Roy may have used such a quadrant and may have substituted a telescope for one of the slotted sights.

In the next letter which has been preserved, after some grumbling on Roy's part with regard to the negligence of the Post Office, he refers to the observations which were being carried out (1774–76) by Maskelyne, the Astronomer Royal, to determine the attraction of a

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mountain of known mass and from this to infer the mean density of the earth. In Maskelyne's words, there were three operations to be performed: "(1) To find by celestial observations the apparent difference of latitude between two stations, chosen on the north and south sides of the hill. (2) To find the distance between the parallels of latitude. (3) To determine the figure and dimensions of the hill." The hill selected was Schiehallien in Perthshire, now spelt Schichallion, the Gaelic form being Sith-chaillionn, *i.e.*, the Hill of the Caledonians.

Mr. Charles Hutton, F.R.S., who computed the results, obtained 5·0 as the density of the Earth, the present accepted value being 5·527. It was Hutton who first, at least in this country, invented contours. His Schiehallien calculations were published in the *Philosophical Transactions* of 1778, and he there says that he "fell upon" the method of "connecting together by a faint line all the points which were of the same relative altitude"; by so doing he "obtained a great number of irregular polygons lying within, and at some distance from each other, and bearing a considerable resemblance to each other";—not the first time that a purely scientific investigation has resulted in a valuable practical discovery.

From William Roy.

*Lanark, 26th July, 1774.*

DEAR SIR,

. . . Tho' I had left written directions in the Post Office at Edinburgh with respect to the forwarding of my letters, yet by the most astonishing negligence of the people there, I have only received about half my newspapers and very few letters. This appeared to me so strange that I have wrote to London to inform the Secretary of the General Post Office there of the matter. . . . I must therefore beg, My Dear Sir, that you would be so good as to release my letters in the Coffee House, indemnifying the people there. . . .

My intentions were, when I had the pleasure to see you, to return from Shihallan by the way of Edinburgh. . . . I took my leave of Maskelyne on the 15th, but I did not quit Strath Tay till the 18th, having some observations Geometrical as well as Barometrical to make on the neighbouring Mountains.

I am glad to hear that the Sector is at last adjusted. . . . The ground for the Base was so very unfavourable . . . that I advised Mr. Maskelyne to level and measure quite across it between the two stations. Ramsden's Barometers do wonderfully well, that is to say, they are uniformly consistent in their own results; though the rule for ascertaining heights by De Luc's method is defective.

In those days, and, indeed, until sixty years later, geodesists were in doubt as to what datum should be used for the measurement of heights. The conception of a sea-surface swinging up and down from a mean position had not been properly grasped. In conse-

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quence, we find Roy, in the following letter, taking "high water neap tide" as his datum surface.

In this letter, also, he writes about his barometer observations. It is remarkable how much time he devoted to this subject, which recurs again and again in his correspondence.

William Roy to Dr. Jas. Lind, Princes Street, New Town, Edinburgh.

*Lanark, 5th September, 1774.*

. . . I carried one of my Barometers to Glasgow on the 29th, leaving the other here. By three excellent corresponding observations, which differ from each other but a few feet, the station of my Barometer here is above the level of high water Neap Tide (which I take to be the mean height of the Sea) at Glasgow New Bridge 663½ feet. . . .

I have had another long letter from Maskelyne, who is now on the north side of the Hill (Schiehallien); nothing is yet fixed with respect to the distance of his two stations. He wants my Telescopic Spirit Level, which I shall endeavour to convey to Perth for his use when I arrive in Town; or I may perhaps send it to your care this week to be forwarded there.

On the 2nd June, 1775, he writes:

There are no accounts as yet from Captain Cook, neither do I hear a single word of Mr. Banks [President of the Royal Society] going any voyage to distant parts of the world. Tho' this morning he sets sail with Lord Sandwich to see the different Dockyards, on which trip he will be absent five or six weeks. . . .

I have been engaged for some time past in making experiments on the expansion of the Mercury, which I have after much plague and trouble ascertained at last. It is progressive and arithmetical. If I can get the paper ready in time it will be given to the R.S., before the Recess; if not, I must put it off until winter.

And on the 15th June:

. . . I have now and then found a degree of superior heat at the Top of St. Paul's, compared with that in the Churchyard. The same happened at Hampstead the other day, when compared with the Temperature in the yard of my house. The smoak might occasion that at St. Paul's, I know not the reason of the last.

Do be so good as try thermometers in the Sunshine, free of reflected heat from walls, and also in the shade. Passing clouds make a very considerable difference, as I found the other day at Hampstead, the difference being 5° or 6°—tho' that in the shade continued unaltered. . . .

American affairs look muddy; we may possibly have something else to do than observe Barometers. . . .

American affairs got "muddier." Already, in fact, we were at war with the Colonies, which formally declared their independence

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on the 4th July, 1776. We were at war with the French in 1778, with Spain in 1779, and with Holland in 1781, in which year the American war came to an end by the surrender of Yorktown to the American and French forces.

During these years Roy appears to have been occupied with headquarter duties in London, but in exactly what capacity is not known. At the outbreak of war in 1775 he was a Lieut.-Colonel in the Army and a Captain of Engineers. He held the appointment of D.Q.M.G., and was still in receipt of his special pay as Inspector of the Coasts and the Country adjacent thereto, so perhaps it was his business to arrange for local defence schemes. On the 7th November, 1775, writing from London, he says that he is " extremely busy " :—

> You will be surprised that I have been so long in acknowledging the Receipt of your obliging favour of the 28th September. The truth of the matter is plainly this that, having been for some time past extremely busy, I could not find time to go to the Mitre to meet any of the R.S. to enquire about Mr. Glennie's paper. . . .
>
> I return you many thanks for the drawings of the antient entrenchments you have been so good as say you would permit me to copy.—I will do it with a great deal of pleasure, and the originals shall be carefully returned. I have never seen any one of the pieces you mentioned. The entrenchment at Lornly (for it is not a Camp) I saw a bad plan of, no way satisfactory, perhaps yours may be better.—I had not, when last in Scotland, time to go to see the work itself. Neither have I ever been at Barry Castle, tho' I have often observed it at a distance. . . . The height of Snowden above the sea is 3,568 feet; the vertical distance of the Barometers, the lowermost being on Carnarvon Quay, was 3,555. . . .

Roy's determination of the height of Snowdon was remarkably good; the accepted modern value being 3,560 feet above mean sea-level.

His expression of thanks for " the drawings of the antient entrenchments " shows that even during this busy time in London he still retained the interest in archæology which he first showed in the early days of the map of Scotland. There are, indeed, many who think of Roy chiefly as an archæologist, and remember his name rather as the author of the *Military Antiquities* than as the founder of the Ordnance Survey. Mr. Macdonald's admirable study, already quoted, gives a very clear account of Roy's activities in this field of learning and of the writing of the *Military Antiquities* and construction of the plates, which now constitute its chief value. Mr. Macdonald shows that the manuscript copy of the book was probably presented by Roy to the King's Library before September, 1774.

The American war put an end, for a time, to all Roy's schemes for the systematic mapping of the British Isles. The few letters of

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this period that remain are full of the war. On the 13th January 1776, he writes:

. . . You see then how matters stand; we are no doubt to have a Body of 17,000 Foreign Troops in America next Campaign, I cannot tell whether any more medical assistance will be necessary, as it has been understood that the lesser Hospital going now out would afterwards be sent to Canada.—The great Hospital still to remain on the coast of the Atlantick. . . .

It is alleged, how truely I cannot say, that Lord S——ch is not so well at C——t as heretofore, owing to his supporting Admiral Greaves, who by all accounts, has behaved with great pusillanimity in his Command.

And on the 22nd February:

There are authentick good news just arrived in 18 days from Boston. Montgomery had assaulted Quebeck in which he with about 90 of his men were killed. Arnold is wounded and taken prisoner with about 300 more. The remainder have retreated to Montreal. We have therefore reason to hope that Quebeck will be safe for the winter, and that now the Succours will arrive in sufficient time to secure it in the spring.

Peace was not signed until 1783, and meanwhile all large survey schemes were necessarily put aside; British official surveys, were, however, about to undergo a change. We are getting to the end of compass sketches and the occasional use of quadrants. The state of mapping at home has its parallel in India. There, Major James Rennell of the Bengal Engineers, the first "Surveyor-General of the East India Company's dominions in Bengal," carried out his surveys with "compass and chain, supplemented by a Hadley's Quadrant for the determination of latitude."* Rennell's work is excellent of its kind, and is intermediate in accuracy between Watson's map of Scotland and Roy's later surveys.

**Roy and Rennell.**—The great surveys of the British Isles and of India have, from time to time, throughout their history, reacted favourably on each other, and it may be of interest to note the rough similarity that may be traced in the careers of Roy and Rennell. Both began their official lives outside the Army, Roy in the Post Office, Rennell in the Navy; both became Engineer Officers; both were elected Fellows of the Royal Society, and both received the Copley Medal from that Society; both Roy and Rennell felt a deep interest in history and archæology, shown in Roy's case by his *Military Antiquities of the Romans in North Britain*, a work which

* *The Journals of Major James Rennell* (1764--67). Edited by T. H. D. La Touche. Calcutta, 1910.

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is still consulted for its plans, and in Rennell's case by his *Geography of Herodotus*, which a high authority pronounces as still of value; both were present at various military actions against the French; and Roy was the founder of the Ordnance Survey and Rennell of the Survey of India.

They must have known each other well. In 1779 Rennell, after returning from India, took a house in Charles Street, Cavendish Square; Roy was then permanently in London, in Argyll Street. Rennell was elected into the Royal Society in 1781, of which Society Roy had been a Fellow for fourteen years. Shortly before Roy's death he submitted to the Court of Directors of the East India Company some proposals for a trigonometrical survey of India, and Rennell supported these proposals.

**The Surveys of France.**—In 1783, at the end of the war, the surveys of France, both geodetic and topographic, were in a more advanced state than those of the British Isles; and, as the next impetus towards the formation of a national survey in this country came from France, we may, for a moment, glance at the state of affairs across the Channel.

In 1669–70 the Abbé Picard had carried out the first triangulation executed on the soil of France, using the method first adopted by Willebrord Snell in Holland in 1617. Picard's Triangulation consisted of a meridian chain from Paris to Amiens, and his object was to determine the dimensions of the earth. The radius of the earth so determined was used by Newton in 1682 to verify the theory of universal gravitation. Between 1683 and 1718 the two elder Cassinis, father and son, prolonged the chain to Dunkerque on the north, and southward to Collioure.*

The third Cassini, known as Cassini de Thury, with La Caille, revised the arc, which is generally known as the Meridian of France. The revision was carried out in 1739–40. This Cassini began, in 1744, the construction of a topographical map of France, based, no doubt, on triangulation where available. As it is easy to get confused with the dates of the four Cassinis, it may be noted that Cassini de Thury was born in 1714 and died in 1784.

**The Surveys of Great Britain in 1783.**—At the time of the Peace of 1783 there was in Great Britain no systematic triangulation, if we except the little, rough work that Roy himself had carried out in Scotland. Although the plane-table, in practically its modern form, had been known for at least two hundred years†, it appears that all the official sketches and reconnaissances were executed with the magnetic compass, and the order of accuracy was just that of a

* Revue Scientifique. Article, *La Méridienne de France*, by Colonel Perrier. 8th September, 1923.

† *Early Science in Oxford*. R. T. Günther. Vol. I., p. 372.

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military compass sketch. Roy's intention to stiffen up Watson's map of Scotland, with a trigonometrical framework, had never been carried into effect. His efforts to establish a national survey department had been put aside, as a consequence, first, of the Seven Years' War, and later of the war with America. The maps of this country were due to private effort and were inferior in accuracy to those produced by Major Rennell in Bengal. Neither in geodesy nor in topography had our great-grandfathers any reason to be content with the state of affairs at home. But this state of affairs was about to be changed.

*(To be continued.)*

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# *HANGAR ERECTION IN IRAQ.*

*By* MAJOR R. HAMILTON, R.E.

IN 1921 it was decided to begin the erection of large steel hangars for the Hinaidi aerodrome near Baghdad.

Up to that time only machines of the two-seater type had normally to be accommodated, but the decision to add troop-carrying machines to the Air Force in Iraq, and to form an Aircraft Depôt there, necessitated the provision of a much bigger type of shed than had hitherto been sufficient. Between October, 1921, and the spring of 1923 the following were erected :—

3 " F " type hangars.
1 " H " type hangar.
2 " German " hangars.
2 " Baghdad " hangars.

This work, except the completion of the " Baghdad " hangars, which was done after the unit had left, fell to the lot of the Sapper and Miner Co. at Hinaidi (No. 63 Field Co., Q.V.O. Madras S. & M.), supplemented, as far as possible, by civilian labour, Indian and local. As the work was somewhat outside the ordinary run for a field company and had to be carried out with limited local resources in labour and plant, an account of it may be useful.

A brief description will first be given of the various types of hangar, followed by an account of the methods used and a few details regarding time and labour, and remarks on personnel.

## I. DESCRIPTION OF HANGARS.

### (*a*) " *F* " *Type.*

These hangars, as will be seen from the plan and section (*Figs.* 1 and 2) have a main room, 203 ft. by 103 ft. (centre to centre of columns), capable of taking six of the Vickers-Vernon machines, and a " lean-to," 203 ft. by 21 ft., behind. The central doorway is 100 ft. wide with two doorways of 50 ft. width each side ; the clear height under the door girders and inside is 28 ft., the top of the roof being 50 ft. above ground.

The four front columns ABCD support the three girders over the doorways. The roof is carried on 14 trusses, which are bolted in rear to a row of columns along EF ; in front, two trusses are bolted

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to the columns BC and the remainder to the vertical members of the girders AB, BC, CD.

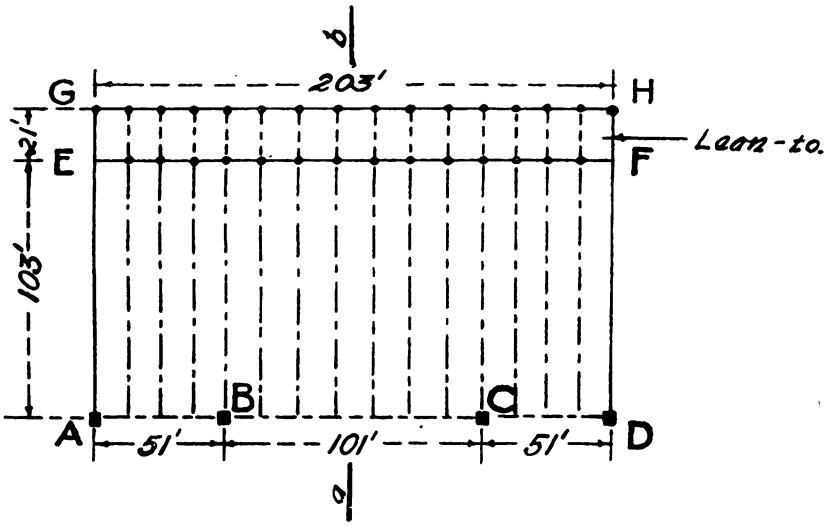


FIG. 1.—Plan of "F" Hangar.

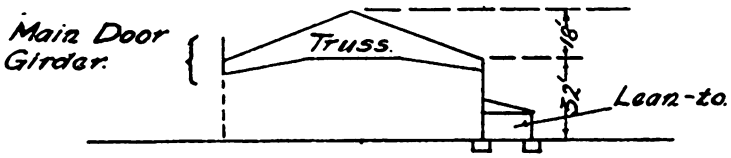


FIG. 2.—Section on *a*—*b* along a Central Truss.

Stability against wind pressure is chiefly insured by the lean-to, the columns along EF being supported from the lean-to columns along GH by the roof-trusses of the lean-to; these latter trusses and the lean-to columns are of very heavy section and the foundations of the latter are heavier than those of the main columns.

The gable ends AE, FD, are each built up of 9 columns and stiffened by a wind girder along them, 28 ft. above ground.

(*b*) "*H*" *Type.*

The "H" type shed is similar in area and door-space to the "F," but is of entirely different design (see *Figs.* 3 and 4). The heavy columns KLMN support two deep girders (VX, WZ in elevation) which practically carry the entire roof. A series of seven "half-trusses" project from each girder on the inside on the cantilever principle, and are joined together at their ends along the line OP. They are balanced by similar sets of half-trusses on the outer sides, which are attached to light columns along QR, ST. There is a framing of light columns along the back QS, and the lean-to is merely a lean-to and nothing more, built of quite light

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sections. It will be seen that by this arrangement the roof skeleton is pretty well rigid in itself, and, provided the four main columns are strong enough against bending at the points V and W, there is little overturning tendency in a wind; as a result, the columns, other than the four main ones, have little strain on them or their foundations.

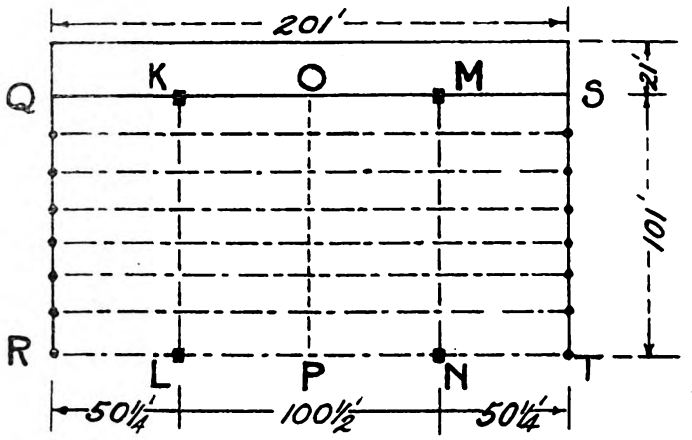


FIG. 3.—Plan of "H" Hangar.

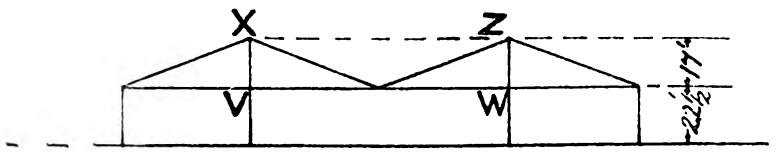


FIG. 4.—Front elevation of "H" Hangar.

*"F" and "H" Types Compared.*

A comparative table of some of the quantities of materials used in the "F" and "H" hangars is given below; it must be remembered that, while the areas are similar, the clear internal height in the "F" is 28 ft. as against 22½ ft. in the "H," and also that the former was designed for Trafford tiles instead of C.G.I.; the great economy of the "H" type is in the foundations, which are only a fraction of those of the "F."

| | *"F" Type.* | *"H" Type.* |
|---|---|---|
| Steel in columns (including wind girders) ... ... ... | 44½ tons | 14 tons |
| Steel in girders and trusses ... | 69 tons | 59 tons |
| Concrete in foundations ... | 345 cub. yds. plus 74 for doors | 46 cub. yds. |

The purlins and the intermediate framing generally on sides and roof are all steel in the "F" (70 to 80 tons), and timber in the "H,"

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so comparison in this respect is difficult. The former, though doubtless more expensive, is much quicker to erect.

(*c*) *"German" Hangars.*

A German firm had erected a shed at Basra before the war, presumably for storage purposes. The Chief Engineer decided to acquire this and bring it up to Hinaidi to provide additional accommodation for the two-seater squadrons. This shed was a closed-in one, about 230 ft. by 98 ft. The framework of the shed consisted of a series of nine trusses, which were jointed to their supporting columns to form what were practically steel arches (see *Fig.* 5). It was put up at Hinaidi in two halves, so as to make two hangars, 115 ft. by 98 ft., with an open end to each as a doorway. This necessitated duplicating the centre arch, which was carried out in the company's field workshop. Lean-to's were added and the sheds strengthened in other ways.

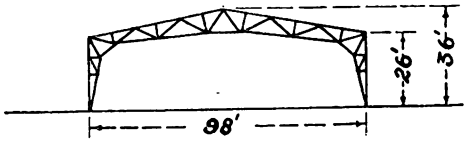


FIG. 5.—"Arch" of German Hangar.

The chief interest of this shed lies in its extraordinary economy of steel, though the shed cannot fairly be compared with the other hangars, as it was not intended for such use as the latter. To take one detail as an example, the purlins were spaced 8 ft. 3 in. apart and had a span of 23 ft. from truss to truss; yet they were only 4 in. by 2 in. "I" beams, weighing about 6 lbs. to the foot; the roof covering was only light C.G.I., yet the lightness of the purlins is remarkable, nevertheless, when compared with those, say, of the "F" hangar—spaced at $3\frac{1}{2}$ ft., spanning $14\frac{1}{2}$ ft., and weighing $9\frac{1}{2}$ lbs. per foot.

(*d*) *"Baghdad" Hangars.*

Finally, two hangars of local design and made up, as regards columns and side-framing, in the E. and M. workshops at Baghdad, and as regards roof members in the field workshop, were erected to supplement the "F" hangars in giving accommodation for the Vickers-Vernon squadrons. Each was a simple double shed with 80-ft. trusses.

## II. DESCRIPTION OF WORK.

(*a*) *Preliminary Work on Steel—Transport, Sorting and Straightening.*

When orders were received to start work on the first two "F" hangars, these sheds were represented by some 500 tons of steel

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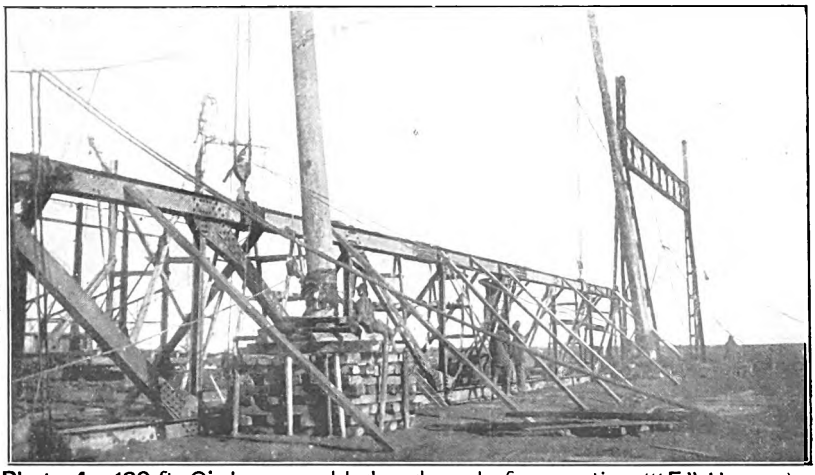

Photo 4.—100-ft. Girder assembled and ready for erection ("F" Hangar).

Photo 5.—Straightening a bent column with improvised oven.

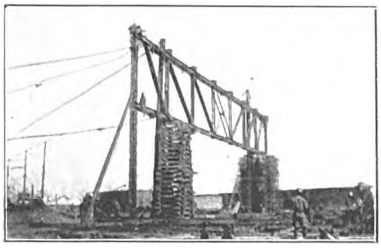

Photo 6.—100-ft. Girder in position ("H" Hangar).

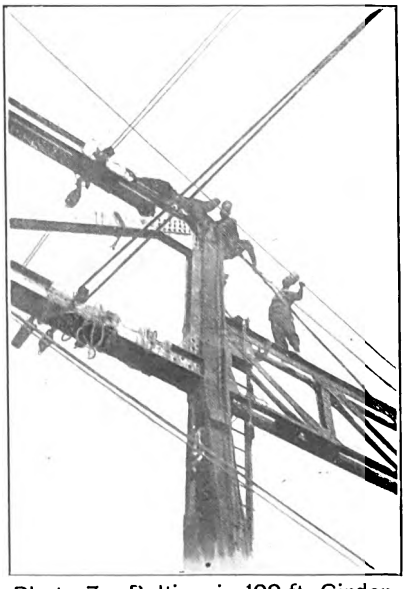

Photo 7.—Bolting in 100-ft. Girder ("F" Hangar).

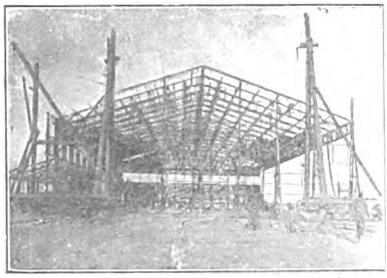

Photo 8.—"F" Hangar nearing completion.

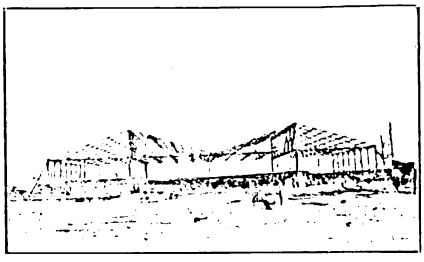

Photo 9.—"H" Hangar nearing completion.

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lying on the bank of the Tigris, where it had been previously unloaded, also by the Sapper Company, from barges. The pieces varied in size from columns 40 ft. long and weighing 2 tons, down to short lengths of angle iron apparently almost infinite in number and variety. They were most thoroughly mixed up and also, due to bad loading in ship or barge, were most of them bent, even many of the heavier columns. By no means the least problem to be faced, therefore, was the transport of the steel to the site, nearly three miles away, and getting it sorted and straightened.

The transport was done almost entirely on the Cantonment light railway. The steel was loaded either in bogey trucks or on " swivel trucks," the latter being made to take columns by mounting a U-shaped bracket, pivoted on its centre, on the frame of an ordinary tip-truck. As waiting to make up trains would have involved much delay, trucks were hauled away as soon as loaded by harnessing mules to them, from one to four, as necessary, arranged tandem fashion.

The sorting of the steel, though a very long and tedious job, calls for little comment except to emphasize the enormous value of really thorough, unmistakable, marking. The " H " hangar had been already erected once at East Fortune ; it had been very thoroughly marked before dismantling and a " demolition book," giving details of the marking, was sent with it. The result was a saving of very many " men-months " as compared with the earlier hangars, in which the marking was very sketchy.

The straightening of the lighter members did not offer great difficulty, the use of a large jim-crow or heating and hammering the member on a straightening slab being usually sufficient.

The heavy columns were a much harder problem. These columns were mostly single R.S.J.'s, sometimes reinforced with flat iron plates along the flange. The principle adopted was to lay a couple of straight heavy columns on the ground on edge and the bent one on top of them on the flat, separated by packing pieces. The bent column was clamped to the lower ones by putting channel irons below the latter and above the former and connecting them with long bolts (the anchor bolts and channels for the foundations were found very suitable for this). The bent column was then drawn down by screwing up the bolt nuts till the bend had been more than taken out. On releasing it after some hours it would spring back somewhat and probably be straight. This was for mild bends. For worse ones heat was necessary. The same arrangement was used and a small oven of brick and mud, with a pipe chimney, was built round the bend in the column. The oven was then heated up and when the steel was hot enough the column was drawn down into line as before by screwing up the bolt nuts. (See *Photo* 5).

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(*b*) *Foundations.*

Columns were anchored down to large concrete foundation blocks by anchor bolts and channel irons. Great accuracy in the setting of the anchor bolts was, of course, essential. The following method was found satisfactory :—

A system of pegs is laid out over the site with theodolite and steel tape, arranged so that every pit can be crossed by two lines from peg to peg at right angles ; each peg has a nail driven into its head, marking the exact line. All key pegs at the end of rows are made large and set in concrete so that displaced pegs can be reset from them. Wooden templates are made for each type of foundation, with holes drilled in them for the holding-down bolts (usually four). The fixing of these will be clear from the diagrams (*Figs.* 6 and 7).

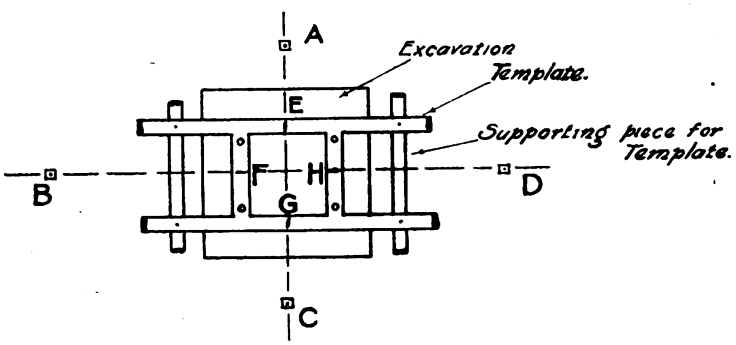


FIG. 6.—Plan of Excavation with Template.

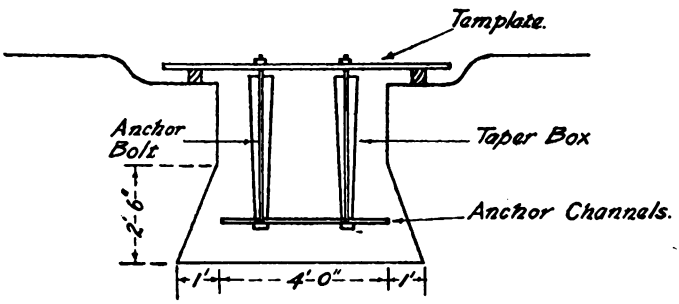


FIG. 7.—Section of Excavation, showing Anchor Bolts, Template and Taper Boxes.

All that is necessary is to get the marks EG and FH under the lines stretched between AC and BD, by means of plumb bobs. For levels, special level pegs are driven in near each pit, set from a central bench-mark. The N.C.O. who is fixing templates levels from this with a mason's level and straight edge, making minor adjustments by turning the nuts on the bolts. Templates, when ready, are checked by an officer and initialled by him.

Before columns are erected a space needs to be left round the

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anchor bolts to allow some play in them, and also for slight horizontal adjustment of the column if required. This is done by putting tapering wooden boxes round them, as shown in the diagram; these, of course, must be removed when the concrete has set, and to enable this to be done the boxes should be well-greased outside and should be pulled up a little after the concrete has had some hours to set. Otherwise they cannot be removed at all and burning them out is difficult.

Slight adjustment of columns in a vertical direction is allowed for by making the temporary level of the top of the foundation $\frac{3}{4}$ in. below final level and supporting the base of the column on iron wedges and packing pieces. When the whole steel frame is erected and squared, the space below the base-plate and round the anchor bolts is grouted in with a 1—1 mixture of cement and sand. When foundations are complete, nails are hammered into the concrete on the centre lines, and the base-plates of the columns, when erected, are squared with these.

The foundations for the "F" hangar being heavy (419 cub. yds. each), a large daily out-turn was necessary to get them in quickly.

The proportions of the concrete were 4—2—1. The ballast was, at first, broken brick and latterly, shingle, brought by train from the hills. Mixing was done in a mechanical mixer, the ingredients being brought on roller-ways in wooden boxes to a hoist and tipped into the hopper by two men on a platform. Water was fed in by a pipe from a main, and when a "mix" (10 cub. ft.) was ready it was run into a tip-truck and pulled by a mule to the pit where it was needed. The brickbats were broken in a crusher driven by the same engine as the mixer.

The foundations for the third hangar were considerably reduced by adopting the system of making them partly wedge-shaped. It was found that the hard, compact clay soil would easily stand at an overhang of 2/1; pits for the concrete were therefore made with vertical sides at the top and sloping outwards at the bottom, the base being made slightly bigger than that of the original foundation and the top, of course, much smaller (see *Fig.* 7). The labour of undercutting was cheap in comparison to the value of the concrete saved.

(*c*) *Erection of Columns.*

The only point in which this differs from raising an ordinary spar is in the necessity for letting the base-plate down from above on to its four anchor bolts. The following was found to be the easiest and quickest way:—Wooden packing pieces were placed on the concrete, thick enough to keep the base of the column above the bolts. The column was laid with the edge of its base on the packing pieces, and a small steel collapsible gyn was set up over the

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foundation so as to be just clear of the column when upright. The column was pulled into a vertical position from a derrick or a neighbouring column, and it was then kept upright by guys, while its base was raised clear of the packing pieces by the gyn, and lowered on to its anchor bolts when the packing pieces had been removed.

A column was plumbed by hanging a heavy metal weight on a wire from a bracket or wooden cross-piece fixed near the top of the column, the weight being steadied in a bucket of water. Distances from wire to column at top and bottom could then be measured by foot-rule and compared.

(*d*) *Erection of Girders.*

The heaviest girders to be raised were the main door girders in the "F" hangars, 100 ft. by 11 ft., weighing 10 tons, and the main girders of the "H" hangars, 100 ft. by 15½ ft., weighing 12½ tons.

Each girder was raised by two wooden derricks, extra height being obtained when necessary by mounting the derricks on cribs resting on earthen revetted platforms.

The chief lesson learnt was the necessity (if the plant used is in any way doubtful) for some safety arrangement which will both avoid disaster if anything gives way, and will also enable the weight to be taken temporarily if adjustments to derrick or tackle become necessary. In the case of the "F" hangar girders (the strength of the derrick spars not being too great) this was provided for by safety tackles from the girder columns themselves, passing through the web of the girder to the lower boom. In the case of the "H" hangar this precaution was at first omitted and the end of one girder was dropped when within an inch or two of position by the failure of a winch. After this, light timber cribs were built up under each end of the girder as it rose.

When bolting girders into their columns, and in all jointing work of this kind, constant use has to be made of drifts made from round steel bars forged to a taper. A determined and experienced man with a hammer and drift will make the corresponding holes in two members coincide sufficiently to get bolts in, when at first they show no inclination at all to do so.

(*e*) *Erection of Trusses.*

The heaviest trusses, those of the "F" hangar, were 103 ft. long by 22 ft. high, weighing 4 tons, the peak when in position being 50 ft. from the ground.

It appeared that the rapidity of erection of the "F" hangars would be largely governed by the speed with which the trusses (14 to a shed) could be put up. To enable this to be done as quickly as possible two movable gantries were made. The base of each was a platform about 23 ft. by 23 ft., consisting of a frame of 12-in.

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by 12-in. timber decked in and mounted on four metre-gauge railway trolleys running on two parallel lines of rail (see *Fig.* 8 and *Photo* 2).

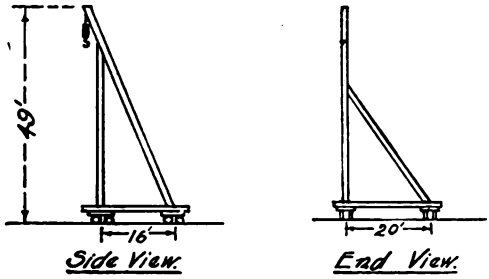


FIG. 8.—Gantry for lifting Trusses ("F" Hangar).

On this base was erected a long sloping spar resting on a vertical timber column and strutted and braced sideways to the other side of the platform to give stability. The fall of the tackle was passed round a winch on the platform. One gantry had a second arm mounted for raising the back columns, and both had light jibs for lifting the steel purlins on to the truss when the latter was up. These machines took some time to make, but were very effective, and as they were used for three hangars (42 trusses) in succession, they were probably well worth while.

In the case of the "German" and "Baghdad" hangars, where the weight of the trusses and the height to be lifted were less, two ordinary spar derricks were used; each of these had two horizontal lifting poles lashed to it some 3 ft. from the ground so that it could be lifted and moved along from one truss to the next without lowering.

A mishap that occurred to the first truss of one "F" hangar is instructive. The peak of the truss, after erection, was supported by guy ropes; after some hours one of these gave way, so that the truss fell over sideways, badly twisting the back column to which it was attached. The guy in question was of 3-in. cordage in very good condition; it was discovered, however, that on its way to its anchorage it had been bearing against the edge of a steel column; the truss had oscillated in the wind and also, probably, through coolies knocking against the guy ropes in passing, and this action of rubbing against the steel had frayed through the rope till it could no longer stand the strain. After this steel wire guys were always used.

(*f*) *Covering of Roof and Sides.*

Corrugated galvanized iron was used throughout, fixed by hook-bolts, screws or clips. Hook-bolts were used in the "F" hangars and were the most satisfactory.

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As before, the problem was chiefly one of time. The sheets had their top row of holes punched on the ground and the bottom row when in position on the roof. Intermediate rows were put in at leisure after the roof was otherwise complete.

Sheets were generally raised by packing them in large wooden trays and hoisting them with a tackle by hand, or by harnessing a mule to the fall. For the German hangars the trays were made to slide up long inclined timber planks.

A shortage of hook-bolts occurred at one time, but it was found possible to turn out several hundred a day in the field workshop out of $\frac{1}{4}$-in. round iron, nuts of this size being already available from small bolts. The iron was cut to a gauged length, gripped in a wire strainer (bushed to fit the iron) in a vice, and the end held in another wire strainer and bent over; the hook-bolts were then passed to stock and die men for screw-threading.

(*g*) *Erection of Doors.*

This part of the work required probably more accuracy than anything else. The "F" hangar sliding doors are 28 ft. high, and weigh about $2\frac{1}{2}$ tons each, but have to be capable of being moved along by one man.

The door rails had channel iron "sleepers," which were anchored into the foundation with bolts and anchor plates and the whole was embedded in concrete to rail-level. The lower portion of the foundation is concreted beforehand, but the rails and channels should not be concreted in till fully tested by running the doors over them.

The doors were generally raised by pulling them up against a column, the top outer guide being omitted.

It may be remarked that such sliding doors should always have a continuous member along each of their four sides. This was not the case with the "H" hangar doors, which had a vertical and horizontal through-joint (except at the bottom) and were never as satisfactory as those in the "F" hangars.

## III. TIME AND LABOUR.

Work on the site of the "F" hangars began on October 24th, 1921, concreting began on November 14th, and steel erection on December 9th; the first hangar was ready for machines on February 15th, 1922, though doors had still to be erected and various "finishing" work done. The second hangar was finished, including doors, by April 17th, 1922.

Work on the remaining hangars was intermittent, depending largely on the supply of material. The third "F" hangar was completed in June, the "H" type in September, the German

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hangars in October and the "Baghdad" one was nearly complete in January, 1923, when the unit left for Mosul. Perhaps the quickest piece of work was done on the roof of the German hangars; the unloading of the barge containing the trusses (in halves) was begun on September 17th and the trusses were transported to site, assembled and erected, complete with steel purlins, by September 24th. The following table gives the approximate amount of labour in man-days employed on one "F" hangar for the different operations, excluding transport of materials to site.

| | Sapper Ranks. | Unskilled Labour. | Civilian Skilled Labour. |
|---|---|---|---|
| Foundations (survey, excavation, concrete) | 570 | 2450 | — |
| Preliminary work on steel (sorting, straightening, preliminary assembling) | 1110 | 3310 | 1070 |
| Final assembling and erection of steel and putting on C.G.I. ... ... ... | 3240 | 5440 | 218 |
| Painting and glazing ... ... ... | 240 | 240 | 240 |
| Floor (levelling, filling, rolling) ... ... | 40 | 800 | — |
| Total ... | 5200 | 12240 | 1528 |

The above would be equivalent to an average daily strength of 50 sapper ranks, 15 civilian artificers and 117 coolies for four months (105 days) for each hangar.

The unskilled labour (Arab coolies) was generally of low efficiency.

## IV. Personnel.

The organization and supervision of the work mainly fell on the Company subalterns, but two Works officers who were lent to the unit gave invaluable assistance. One, Mr. L. G. Madge, a Civil Engineer, had had experience of similar work in South America (though, as he used wistfully to remark, with much less primitive appliances). The other was Lieut. Morgan Browne, R.A.S.C., M.T., who put up and had charge of the field workshop which was established at the site of the work; Lieut. Browne, who had had a lifetime's experience in almost every quarter of the globe, showed a wonderful fertility of resource in inventing straightening and other devices as well as a remarkable faculty for getting work from people of the most diverse races and tongues.

As regards subordinates, the Indian Officers of the company developed a quite remarkable efficiency in hangar work and could, in the course of time, carry out such an operation as raising a 100 ft. truss with little supervision.

The British Sapper N.C.O.'s were of great value for the more intricate technical work such as straightening columns, the collection and assembly of complicated parts, and repairs to engines.

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The work of erection was always carried out by Sapper parties diluted with Arabs, who helped to pull on ropes and lift weights but did not do overhead work, except in putting on C.G.I.

The Sappers worked with the sustained keenness that one counts on from Sappers of all colours and classes. They rapidly developed a complete indifference as to the height above ground at which they might have to work and would walk along slender steel members 40 ft. or 50 ft. up, quite unconcerned.

The unskilled labour (apart from a few Indian labourers available for the earlier months, who worked very well) was entirely Arab and was not too easy to get good work out of, especially working, as they had to, under Indians. The Indian regards the " bedou " as a complete barbarian, who requires physical violence to make him do or even understand anything. The Arab, on the other hand, regards the Indian as belonging to an inferior race, and deeply resents physical violence from him. The Arab further is inclined to regard all work as a most unpleasant, though sometimes necessary, evil, and never contemplates doing more than the actual minimum that will avert hunger. Hence much unpleasantness. In time, however, as the Arab gang leaders and the Sapper I.O.'s and N.C.O.'s became better acquainted, relations improved, especially as it was impressed on the latter that they would be judged by the way their Arabs worked, not by the amount they were hammered. Task work was always given when possible, but this was comparatively seldom.

Civilian skilled labour consisted of Indian artisans and " locals " ; the latter comprised a varied assortment of Armenians, Assyrians, Jews, etc., some of whom had worked in America ; they were nearly all employed in Lieut. Browne's workshop. Armenians were also sometimes found useful for putting on C.G.I. by petty contract.

Serious accidents to personnel were, happily, few. There were no deaths, except one of an Arab boy who got caught in an engine belt in the workshop. One Sapper broke his thigh by bringing down a steel door on himself when showing some civilian friends round on a Sunday. Otherwise, there were only minor mishaps.

The health of all ranks, British and Indian, was remarkably good. Working on the top of a huge steel cage, a man is fairly thoroughly exposed to the extremes of cold in winter and heat in summer, which Iraq so thoroughly provides. There was, however, practically no sickness. The mental effect of having interesting work to do probably contributed to this.

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# *WHOLESALE DEMOLITION.*

*By* COLONEL G. C. WILLIAMS, C.M.G., D.S.O.

UNTIL 1914 the military engineer was taught "demolitions" as part of his fieldworks course; but, as far as I know, the subject was confined to the actual technical details of calculating, making up and firing charges. It was not until the Great War that the possibilities of demolition on a grand scale became apparent.

The post-war text-books, *i.e.*, *Field Service Regulations*, the *Manual of Fieldworks*, and *Military Engineering*, Vol. IV, speak of delaying the advance of the enemy by demolitions: but my excuse for this article is that the possibilities of wholesale demolition as a defensive weapon are not generally appreciated.

In October, 1914, the 9th German Army made a deliberate withdrawal from the Vistula back to the Silesian frontier, a distance of 150 kilometres, with the object of disengaging itself from attacks by a greatly superior Russian Army. In this retreat we see for the first time the real use of demolitions on a big scale in civilized warfare. The German plan was the complete destruction of the railway system and the road communications of Poland west and south-west of Warsaw. Ludendorff, in his *War Memories* (page 87), says: "The communications in our rear were subjected to a special examination, for a retreat might only too easily be necessary. Preparations were made for the destruction of the railways, amongst other things, by placing in readiness an immense amount of explosives"; and again, on page 94: "Our first business was to delay the Russians as long as possible and keep them away from the German railways. The destruction of railways and roads had been prepared for in a very wholesale manner. Experience had taught us that a modern army cannot operate more than 120 kilometres from its railheads. If this is true and we are able to destroy the railways as thoroughly as I hoped, we could count on bringing the Russian masses to a temporary standstill, even without fighting, before they reached our frontier. . . . I had the satisfaction of seeing the enemy's advance gradually slow down, and actually come to a standstill at the very distance I have mentioned."

The Germans did not forget the value they had derived from this first attempt at wholesale destruction. For in their deliberate withdrawal to the Hindenburg line in 1917 all railways were utterly destroyed, even to the removal of rails and the cratering of embankments and cuttings: roads were rendered impassable by the blowing of mine craters 30 to 60 ft. in diameter at every cross-road, cutting and embankment; all machinery was removed or broken; there

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was wholesale destruction of gardens, trees, houses and every form of shelter. And the desired military result, *viz.*, respite from attack, was successfully achieved. The demolition programme was carefully worked out and co-ordinated by the Higher Command ; and it took five weeks to prepare before the retreat began. It was a very fine piece of organization and, in its gruesome way, a very artistic effort.

Sir Douglas Haig speaks of it in his Dispatches in this way : " By this time (19th March) our advance had reached a stage at which the increasing difficulty of maintaining our communications made it imperative to slacken the pace of our pursuit. . . . We were advancing over a country in which all means of communication had been destroyed, against an enemy whose armies were still intact and capable of launching a vigorous offensive, should a favourable opening present itself. In such circumstances the necessity for caution was obvious."

The final retreat of the Germans in November, 1918, affords an example of the use of wholesale demolition in a forced retreat. To quote from Sir Douglas Haig's final dispatch : " At the time of the Armistice railheads were on the general line Le Cateau, Valenciennes, Lille, Courtrai ; and for many miles in front of them bridges had been broken and track torn up or destroyed by mines." This meant that railhead had dropped 70 to 80 miles behind the fighting troops ; and, for lack of communications, the advance of the British Armies was reduced to that of three brigades on each army front, and might, in all probability, have come to a temporary standstill in the course of the next two days.

These examples show that in both deliberate and forced retreats wholesale demolition can play an important part. The European armies of 1914–18 were checked in their advances by demolitions alone, and in one case an army was actually stopped in a distance of 80 miles by the systematic destruction of roads and railways. There is, of course, always the serious consideration of the moral effect on the civil population of carrying out wholesale demolition in one's own or a friendly country ; and it no doubt may sometimes prevent the complete fulfilment of the programme of destruction, which the military situation demands. In the instances quoted the Germans were fortunate in being able to carry out their demolition entirely on enemy property.

The preparation for such wholesale destruction takes time and cannot be kept a complete secret. These are serious objections, particularly as we would always wish to keep our intentions from becoming known to the enemy and at the same time prevent the demoralizing thought of retirement from lowering our own moral. However, wholesale demolition is such an effective weapon, as the Germans proved, that ways and means should be found to include it in our armoury and to make full use of it when occasion demands

*F.S.R.*, Vol. II, sec. 87, says : " Orders for a possible retreat

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should be thought out beforehand, but should not be communicated to the troops before it becomes necessary." This regulation is often read to mean that preparations for a possible retreat should be postponed until the last minute for fear of their demoralizing effect; which is, of course, wrong in view of sec. 144, which reads: "It is the duty of a commander of a force acting on the defensive to include in his plan a scheme for withdrawing his troops in the event of the enemy succeeding in capturing his position."

The scheme for withdrawal will not be complete without its demolition project: and the portions of the scheme, which take time to carry out (including some of the preparations for demolitions), must assuredly be got ready beforehand. This form of demolition is referred to in *Military Engineering*, Vol. IV, as "Deferred Demolition." Preparations for demolitions, though they cannot be completely concealed from one's own troops, need not become known to the enemy until the actual explosions take place; whereas wire, trenches and other such defensive measures are much more difficult to conceal. During the war the sight of lines of rear defences usually produced the reassuring feeling that wise precautions were being taken in case the worst should happen, and such sights never created the impression that retreat was imminent. It only remains, therefore, that troops shall be educated to the fact that no defence scheme is complete without its demolition project. Then preparations for demolitions will never be the cause for alarm or despondency, and will always be made in plenty of time.

It may be argued that with the introduction of more and more tanks, destruction of communications will not be so effective as it was in 1918, for armies will become less and less dependent on road and rail communication. This may be true to a limited extent: but still, in most theatres of war communications (roads, railways or tank-echelons) must needs follow certain lines of advance; and, besides destroying roads and railways, supplies, wells, houses and shelters, it will be possible, by well-placed mine-fields, to delay tanks also.

Having established the principle that wholesale demolition is a defensive weapon to be made full use of when occasion demands, it only remains to learn how to handle it. The success of such a project lies in co-ordinating the work of destruction with the movements of the troops using the communications, shelter, water, munitions and stores, so that their wants are adequately met, while nothing remains for the use of the pursuing enemy. Nay, even more, the enemy must also reap the benefit of delay action mines which will continue to destroy as he rebuilds.

It is by the study of the German demolition projects in their retreats of 1914–17–18, and by means of exercises and schemes in wholesale destruction worked out in peace time by Engineer commanders and by staffs that we shall learn to become proficient in this necessary form of frightfulness.

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## *RECENT DEVELOPMENTS IN OIL-ENGINE PRACTICE.*

*By* LIEUT. J. T. GODFREY, R.E., and LIEUT. K. W. MERRYLEES, R.E.

THE class of oil-engine generally known as the Diesel or Semi-Diesel, but better comprehended, perhaps, under the term "heavy oil-engine," has hitherto required for its running an amount of accessory apparatus which has considerably detracted from its otherwise outstanding merit. This apparatus is comprised, in the high-compression type of engine, of the air-compressor, air-bottles, and valves needed to inject the fuel into the cylinder, and in the low-compression type, of the external heating devices required to start combustion.

Of late years, the method of fuel introduction used in the latter type of engine, and known as "solid injection" has encroached more and more on to the field of the high-compression Diesel. Solid injection was evolved from the vaporizer valve used on engines burning paraffin or other light oils—for example, the Hornsby-Ackroyd. In these machines a pump driven by a quick-acting cam on the half-time shaft forced a charge of fuel through a small hole into a special partition of the cylinder (the hot bulb). Owing to the low-compression pressures then used, the hot bulb had to be heated externally for some twenty minutes before starting up, and was, by its construction, intended to remain at a somewhat higher temperature than the rest of the cylinder during work. Only by means of this excess temperature could ignition take place.

An immediate advance was made by raising the compression pressure to that at which ignition is spontaneous. This necessitated stronger construction of the engine and fuel pump and greater care in the design of the sprayer: efficient combustion depended less on the temperature of the hot bulb and more on the complete atomization of the charge.

The success achieved in these experiments led to the use of the method with still higher pressures, and engines now constructed use solid injection on compression pressures of 400 to 450 lbs. per sq. in. The method is applicable without great difficulty to the highest pressures met with in engines using the Diesel cycle: but there is a tendency among designers towards the use of lower pressures than was the case in earlier years. Solid injection is particularly advantageous in that the risk of pre-ignition is very greatly reduced, owing to the fact that there is no permanent air pressure, tending to force fuel into the cylinder at all times, as in the other system; consequently, the extremely heavy construction required in the

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cylinder heads of air-injection Diesel engines is rendered unnecessary in the solid injection type.

The blast-air injection type of Diesel had, since its inception, almost a monopoly in the use of crude oils. Solid injection, originally designed for paraffin, is now perfectly applicable to crude oils, even the heaviest being amenable when passed through a heater warmed by the exhaust. It can be easily adapted to burn any of the recognized liquid fuels, including vegetable oils, such as palm-oil and nut-oil, obtainable in the tropics, and it operates with great efficiency on the cheapest of them. Even tar-oil can be burnt by the use of a " pilot " fuel valve of a special dual construction which injects about 7 per cent. of oil of lower-ignition point slightly before the main charge of tar-oil, thus firing the latter. Crude alcohol, too, can be burnt by a similar type of valve, and no signs of erratic action have been noticed in engines working on this fuel. In the Ruston-Hornsby type of ' pilot ' fuel valve in the smaller sizes of engine, the " lead " of the priming charge is automatic : this does away with the necessity for two separately-timed injectors.

It will be seen that the solid-injection high-compression engine eliminates the bad points of the two types of engines hitherto used. It is unnecessary either to have a messy blow-lamp applied for twenty minutes before starting, as was the case in one type, or to have the permanently running air-compressor required by the second. The fuel supply system of the former is slightly, and of the second enormously, simplified. Above all, the advantage of immediate starting from cold, a great feature of the air-blast Diesel, is retained, while the efficiency is proved to be on a par with the best ever reached, even on engines with 50 lbs. higher compression pressure, chiefly owing to the elimination of the negative work of the compressor. Another merit, from observation, appears to be that the presence, by accident, of an excess charge of fuel in the cylinder does not lead to dangerous pressures.

The details of present construction are as follows :—

*The Fuel Supply* (*Fig.* 1) :—

The fuel (or paraffin for starting and shutting down) is fed by gravity to the heater, an iron box bolted to the exhaust pipe, and is drawn from the heater by the pump. The pump-plunger is operated by a cam on the half-time shaft, but it also may be operated, or held away from the half-time shaft cam, by a hand lever and cam ($C_3$). The fuel is drawn in through the valve V, and delivered through $V_2$ direct to the atomizer. A constant quantity is drawn in on each stroke of the pump, but the amount delivered to the atomizer is varied by the valve $V_3$. This valve is held open by a lever and cam ($C_2$), controlled by the governor. A portion of every charge is thereby returned direct to the fuel tank. The initial setting is made by the set screw S.

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The " Tangye " system differs in that the valve V3 is omitted and the governing is obtained by varying the length of stroke of the pump plunger.

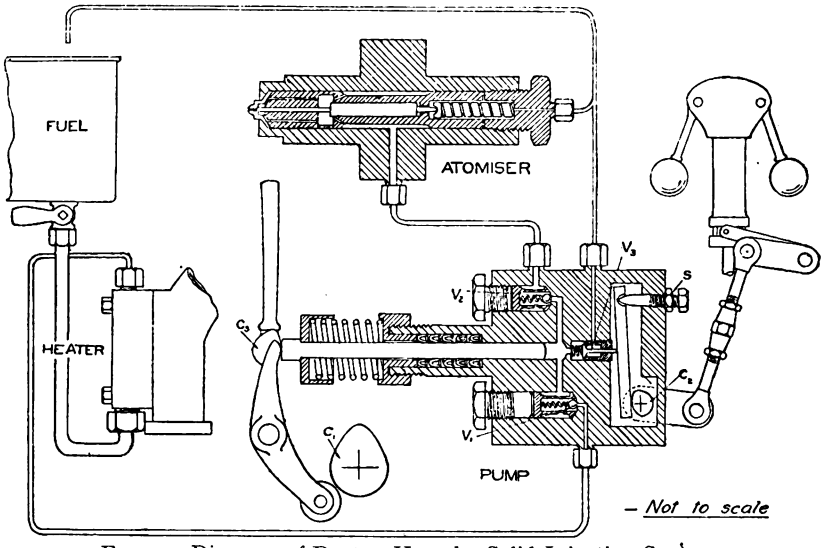


FIG. 1. Diagram of Ruston-Hornsby Solid-Injection System.

*The Atomizer* (*Fig.* 2) consists of a steel barrel which contains the following items :—

(*a*) *The Nozzle.*—This, in the Tangye pattern shown in *Fig.* 2, has a small round hole through which the fuel is sprayed. The Ruston pattern has a fine slit. The back of this hole is the seating for the needle valve which controls the fuel. When in position this nozzle projects into the combustion chamber of the engine.

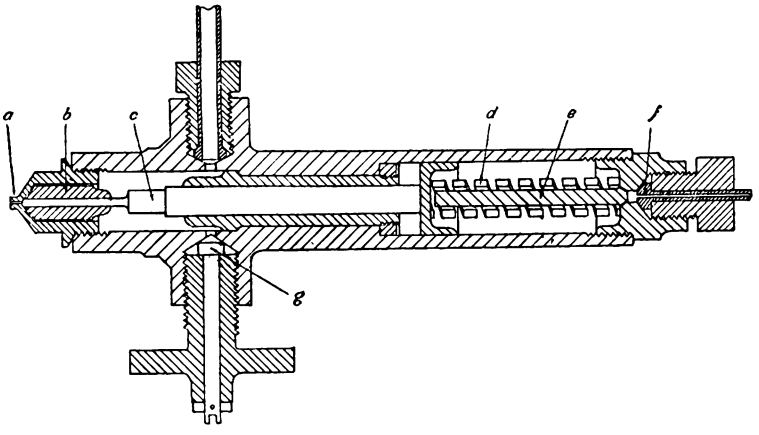


FIG. 2. Fuel Sprayer or Atomizer (Tangye).

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(*b*) *The Diffuser.*—This fits close against the nozzle and helps to break up the fuel by passing it through a number of fine longitudinal slots or holes.

(*c*) *The Needle Valve and Piston.*—This is normally held forward on the seating in the nozzle by the spring (*d*), but when the pump forces a charge into the atomizer, the piston is forced back against the stop (*e*) and the charge driven past the now lifted needle valve and through the nozzle.

(*f*) This is a leakage drain for fuel forced back past the piston (*c*). The air release valve (*g*) is opened when the pump and fuel pipes are being filled before starting.

The starting operation is exceedingly simple. The smaller sizes can be swung by hand and the larger by air-blast at 200 lbs. per sq. in. until the speed is sufficient to carry the engine over compression. The air-valve is then shut, the usual half-compression cam disengaged, and the pump plunger dropped by the cam C3 (*Fig.* 1) into the running position on the cam C. The engine will then fire and can be run up to speed, changed over from paraffin to heavy oil, and put on load very quickly.

The range of sizes in which these engines are made is very wide: both the horizontal and vertical types are obtainable. These facts are best expressed in a table of data for a few of the many types:—

TABLE OF DATA.

| Type. | Max. H.P. | R.P.M. | Consumption in lbs. per Hour. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | At Continuous Working Load. | At Max. Load. | At Half Working Load. | |
| Horizontal | 16 | 300 | ·485 | ·505 | ·56 | Engines are tested to 20% above working load. These consumption figures are guaranteed plus or minus 5%. |
| | 52 | 240 | ·44 | ·455 | ·505 | |
| | 100 | 190 | ·43 | ·445 | ·495 | |
| | 170 | 170 | ·43 | ·445 | ·495 | |
| | 84C | 250 | ·445 | ·465 | ·515 | |
| | 104C | 240 | ·44 | ·455 | ·505 | |
| | 340C | 170 | ·43 | ·445 | ·495 | C = coupled side by side. |
| Vertical | Max. H.P. per cylinder. 55 | 300 | ·44 | ·455 | ·515 | Made as 1-, 2-, 3-, 4-, or 6-cylinder engines. |
| | 82 | 275 | ·43 | ·445 | ·505 | |
| | 110 | 250 | ·43 | ·455 | ·505 | |
| | 130 | 220 | ·43 | ·445 | ·505 | |

Max. size at present obtainable, 750 h.p. for continuous work.

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The above consumptions are on fuel oil of not less than 18,000 B.Th.U. per lb., specific gravity not greater than 0·95 at 60° F. Flash point to be greater than 150° F. and less than 215° F. (closed test). The governor-controlled variations of speed are not to be greater than 4 per cent. increase from maxm. to no-load, or 3·84 per cent. decrease no-load to maxm.

Messrs. Tangye, Ltd., who confine themselves to the horizontal type, have kindly supplied figures of a test by Mr. W. A. Tookey, M.I.MECH.E., M.I.A.E., on one of their 70 B.H.P. horizontal engines, showing a consumption at 73 B.H.P. as low as ·389 lbs. per B.H.P. hr. on fuel of 18,200 B.Th.U.S. per lb. net. Their guarantee figures are naturally somewhat higher. On the other hand, as the results obtained at a well-known central power station equipped with two Ruston engines coupled to 250 kw. dynamos, the consumption on full load at 95 r.p.m. is, under working conditions, ·38 B.H.P. hr.

As regards cost, these engines are somewhat more expensive than the hot-bulb type, owing to their necessarily heavier construction, but the running charges would undoubtedly be lower. Compared with the air-blast Diesel, it is probable that their simpler construction would lead to lower maintenance charges.

The advantages for military purposes of this type of engine are self-evident and need only be summarized. There are, firstly, the general merits of high efficiency, ruggedness and long life. There is, in particular, the great gain in simplicity and ease of starting, an important point where changes in personnel are frequent, since, if necessary, only semi-skilled men can take charge. There is the inestimable advantage of an immediate start at any time, power being made available at half a minute's notice, without the necessity for installing either batteries or high-speed petrol engines of short life and a multiplicity of parts.

For small and medium-sized power-station work in military areas these engines are admirably suited in their larger sizes, owing to the reliability and ease of manipulation. It is claimed that a great freedom from cyclic irregularity is obtained, perhaps due to a more accurate control of fuel supply per stroke. Their quick-starting capacity is a great point in this type of work also, where any sudden stoppage of plant on load necessitates the immediate running up of another unit to keep up the bus-bar pressure.

Our thanks are due both to Messrs. Ruston & Hornby and Messrs. Tangye, Ltd., for the permission to make use in this article of the information acquired, and also for the great help given us at their Works.

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# *REPORT ON THE THIRTY-FOURTH CONGRESS OF THE ROYAL SANITARY INSTITUTE, HULL,* 1923.

*By* MAJOR E. D. CARDEN, R.E.

## 1. INTRODUCTION.

THE parts of the Congress dealt with in this report are those referring more particularly to engineering and the conferences of sanitary authorities.

An account of visits to the cement works of Messrs. G. & T. Earle and to those of the Humber Cement Co. is also given, and of a visit to the Beverley Road swimming baths, where water filtration is employed.

Finally, particulars of some of the exhibits at the Health Exhibition are appended.

## 2. GENERAL REMARKS.

To a general observer of the proceedings the attention of this 1923 Congress appears to have been particularly focussed on the following urgent problems of the day, namely :—

(*a*) The housing problem.
(*b*) Cancer.
(*c*) Smoke abatement.

With regard to (*a*), the President, in his inaugural address, stated that he regarded the provision of more houses as the greatest need of the nation to-day, and that the progress of public health was set back twenty years, and much of the effort of sanitarians nullified, by the existing state of the housing of the working people.

Whilst the great importance of personal education in hygiene for the general public was insisted on over and over again during the Congress, the President also pointed out, in his inaugural address, that it is of no use attempting to instil the principles of hygiene into people who live in the many dilapidated and insanitary dwellings which to-day exist in the slum areas of all our towns and cities.

It may here be observed that in the Army hygiene and sanitation instruction may bear full fruit, since the buildings occupied by soldiers are suitable for a study of the science of hygiene and for practice of the art of sanitation.

With regard to (*b*), Cancer, the President, in his inaugural address, stated : " The deaths from cancer have now assumed disquieting

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proportions. This dread disease now claims more victims annually than tuberculosis. At present it accounts for almost one-tenth of our total mortality. I much regret that the outlook in regard to cure is so pessimistic, and that no public health measures are as yet in being to grapple with the disease. I have wondered if it would not be possible for the public health authorities of our large cities and towns to provide means for the education of the public, in regard to the early signs and symptoms of cancer, and, if practicable, to give diagnosis and advice, if not treatment."

With regard to (*c*), Smoke abatement. This question is receiving Government consideration. Two papers were read on the subject, one by Professor J. B. Cohen, "The Smoke Evil," and one by Mrs. M. A. Cloudesley Brereton, "Women's Part in Smoke Abatement."

Prof. Cohen remarked that it was curious that a nuisance so obvious and widespread as coal-smoke had been tolerated with so much indifference. He thought the proper course was to have a fuel expert at the Ministry of Health, and he emphasized the fact that there are many new forms of kitchen range on the market which do much to obviate the evil, so far as domestic smoke was concerned.

Mrs. Cloudesley Brereton confined herself to dealing with how women can help in the matter. She referred to Sir Napier Shaw as the authority for the conclusion that domestic smoke is responsible for about two-thirds of the smoke nuisance. She said that we know, also, that domestic smoke is, in its composition, far more harmful than factory smoke. For coal is burned in a domestic grate at a much lower temperature than in a factory furnace, and consequently the particles that escape as soot are not so completely burned. Factory soot, consisting of practically pure carbon and ash, is hard and "comparatively" harmless; domestic soot contains a large percentage of tar and acid, and is therefore much more actively destructive.

She stated that, although raw coal is cheaper for continuous use than are the alternative fuels derived from coal, yet, when the household budget, as a whole, is considered, the use of raw coal is not cheaper. Items to be taken into consideration are: storage space for the fuel and its rental, labour in dealing with it, cleaning expenses, and, besides, damage to health and property.

### 3. PRESIDENTIAL ADDRESS TO THE ENGINEERS' AND SURVEYORS' CONFERENCE.

Mr. Elford, M.I.C.E., (Wandsworth) said:—

The construction and maintenance of roads had both a direct and an indirect bearing upon public health.

Road dust was a serious menace to health; the efforts of engineers

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in recent years had practically eliminated that nuisance. Other important services connected with the work of the Royal Sanitary Institute were water supply, sewerage and sewage disposal, the removal and disposal of domestic trade refuse, provision and laying-out of public open spaces, administration of Public Health Acts and Building Bye-laws, erection of schools and infectious disease hospitals, town-planning and housing.

Those which still presented the most difficult problems were sewage disposal, particularly the sludge, refuse disposal, and housing.

## 4. "Portland Cement, Its Manufacture and Uses."

*By* G. V. Maxted, M.I.C.E.*

The author, in his opening remarks, referred particularly to the advent of the rotary kiln and the British Standard Specification as being largely responsible for the present-day reliability of cements manufactured. By reference to a map of England he showed how the industry had grown, and how the rotary kiln had gradually superseded the older types of kiln. Portland cement was first made in this country in Yorkshire, about the year 1870, but the actual home of the industry was centred in the rivers Thames and Medway.

In 1880 the annual output was about 700,000 tons. In 1923, if all works were operating at their full capacity, the annual output would be about four million tons.

The raw materials are not now solely chalk and clay; modern grinding plant enables us to use limestone and shale. The approximate proportions of raw materials used are 3 of chalk to 1 of clay.

The stages of manufacture may be classified as follows:—

(1) Quarrying and digging raw materials; (2) crushing, grinding and mixing; (3) burning; (4) grinding the burnt clinker into finished cement; (5) storage of the finished cement and packing in sacks or casks for transport to market.

### *Stage 1. Quarrying and Digging Raw Materials.*

As this operation can only be carried out in daylight, mechanical means must be utilized to keep pace with the remaining operations of the works.

Every ton of cement requires nearly two tons of raw materials.

### *Stage 2. Crushing and Grinding.*

The chalk from the digger is brought in 6-ton truck-loads and tipped into a crusher, capable of taking 24 tons at a time. From the crusher, the material, now about the size of hens' eggs, passes into a

* See also Section 5.

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rotary screen, pieces too large to fall through the openings in this screen passing into a supplementary crusher, where they are crushed again to the proper size; all then pass into a common elevator which lifts the crushed material into a silo, or overhead storage bin, beneath which the grinding mills are placed. Hand labour is thus minimized and a continuous process assured.

The grinding mill used is generally a combined ball-and-tube mill, of, say, 40 ft. length by 7 ft. diameter and taking about 500 h.p. to operate. The mill is divided into two or more compartments, in the first of which, at the entrance of the rough material, large steel balls are used as the grinding media, in the other compartments smaller steel or hard cast-iron balls are made use of, and sometimes in the finishing chamber a special kind of flint pebble, about the size of large hens' eggs, is used.

In the "wet" process, that mostly used in this country, this material is ground with water, or liquid clay; in the latter case the resultant mixture is called "slurry;" it is of approximately the correct chemical analysis.

The slurry is thoroughly mixed in a washmill, and here the chemist analyses and alters the mixture as required. After leaving the washmills the liquid slurry receives one more and final grinding in "wet" tube mills and is then stored ready for the next process.

*Stage* 3. *Burning.*

The earliest rotary kiln dates from about 1901, when a kiln of this type was erected at Swanscombe, in Kent.

The earlier kilns did not exceed 70 ft. in length and 6 ft. in diameter, kilns to-day go up to 230 ft. in length and 10 ft. 6 in. in diameter in the burning zone, giving an output of about 1,500 tons of cement per week. The earliest rotary kiln produced about 250 tons a week. The large kilns require about 75 h.p. to operate them.

The principle of the rotary kiln is as follows:—It is placed at a slight incline, falling towards the hot or clinkering end, generally about 1 in 25.

The liquid slurry is fed, in measured quantities, into the upper end, and the kiln, slowly revolving, carries the slurry down the kiln towards the clinkering zone.

At its first entrance into the kiln, the slurry meets the outgoing gases, which are then at a temperature of about 800° to 900° Fahr., and all the moisture is driven off.

As the slurry passes down the kiln, the temperature rises, and next the $CO_2$, which is about 38% of the materials when dry, is driven off; it then reaches the clinkering zone, where the temperature is about 2,800° Fahr. The material is there thoroughly and uniformly burnt, and falls out at the lower end, white-hot, into the cooler, which is placed below the kiln.

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The kiln is fed with powdered coal, which is first dried and then ground to a fineness of about 5% on a 100-mesh sieve, in suitable mills, generally of the combined ball-and-cube type. Crude oil could be made use of instead of powdered coal.

In the cooler the white-hot clinker passes through large volumes of cold air (which pass through the cooler into the kiln to support combustion) and, as it issues from the cooler, which is just like the rotary kiln in construction, but much smaller, its temperature is so reduced that it can be held in the hand. The combustion air, therefore, on its passage through the cooler, robs the clinker of its heat, and its temperature is therefore materially raised before it passes into the kiln for combustion; the adjustment of the kiln temperature is a matter of great importance. The kiln operates day and night, as it would involve considerable loss to allow it to cool down.

Dust is baffled off before it can get up the chimney and into the atmosphere, but the heat in the waste gases is not made use of at present in this country, though in America it is used for raising steam. It would also be possible to use it for drying the moisture out of the slurry, prior to its entering the kiln—a proposal which holds out great possibilities of a large increase in output, and of which more is likely to be heard.

After the clinker leaves the cooler it is automatically handled either to storage bins over the grinding mills, or to stock heaps, ready for transport later to the grinding mills.

*Stage 4. Grinding the Clinker into Finished Cement.*

Very fine grinding is a necessity for high-quality cement. Not so long ago, a fineness of 5% residue on a 50-mesh sieve was quite usual, whereas, to-day, the British Standard Specification calls for a fineness of 14% residue on a 180-mesh sieve, or, by comparison, 5% on a 2,500 holes to the sq. in., against 14% on a 32,400 holes to the sq. in.; figuratively speaking, pea-size to flour. Most of the better cements are now offered at 5% on a 180-mesh sieve.

The grinding mills generally used are ball-and-tube mills, or combined mills, as already described.

Grinding mills are preferably placed immediately under the silos or bins into which the clinker is passed after leaving the cooler. These mills are usually run about 132 hours a week, being stopped at week-ends.

From the mills the cement is handled direct to the storage bins in suitable conveyers and elevators, without the intervention of manual labour.

*Stage 5. Storage and Packing.*

The general storage provision is per six week's full output. The silos are now generally constructed of ferro-concrete, they are

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planned as cylinders on end, each of 3,000 tons capacity, and should be arranged so that the cement can be automatically withdrawn and passed out to the packing machines.

Automatic packing appliances are now coming into general use. A vacuum or centrifugal pump process, which feeds the cement directly into the bags, from either the silo or small overhead bins, is most common. The machine automatically weighs the bags and discharges them.

In the Bates system the bags are tied before being filled, and the cement is introduced through a small orifice in the bottom corner of the bag, which orifice is automatically closed by the pressure of the cement around its lip.

## 5. VISITS TO THE CEMENT WORKS OF MESSRS. G. T. EARLE AT WILMINGTON AND THE HUMBER PORTLAND CEMENT CO.

These two up-to-date cement works were visited on separate days. They are here reported on together, points of difference being remarked. At the Earle works the chalk arrives by rail, direct to the works for crushing and grinding and mixing with water and clay to form the slurry. At the Humber works, on the other hand, the chalk is quarried by mechanical diggers on the hill, is crushed and ground at works on the spot, whence it is forced wet through a pipe-line down the hill to the main works, air-pressure being used for this purpose. At the main works it is mixed with clay, to form the slurry, in mixers, 3 chalk, 1 clay. At both works rotary kilns, about 200 ft. long, are used.

It was noticed that at Earle's works a ferro-concrete chimney 198 ft. high is used ; it has an air-space and is lined with firebrick, its diameter gradually diminishing as it rises ; this is achieved by cutting the casing ends as each step is made.

The chimney-top has no collar and is left ragged with the idea of diminishing draughts, which would cause eddies to impede the kiln draught.

The kilns deliver about 7 to 8 tons an hour, and are lined with three different thicknesses of firebrick to accord with the temperatures at various parts of the kiln, 4 in. at the upper end, 6 in. at the centre, and 9 in. at the lower hot end ; there are steps at the change between thicknesses, but this is rather the reverse of detrimental, as it gives pauses to allow moisture to be more completely driven off.

The kilns are rotated by means of a heavy spur and pinion gear, meshing with a heavy-toothed ring encircling the kiln about its centre ; the remaining supports are rollers similarly arranged.

The rotation is slow, perhaps one revolution in rather less than a minute ; 75 h.p. is used.

The clinker, in the form of small pebbles, can be seen dropping

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out at the lower end of the kiln, and at the Humber works the cooler was well seen ; this also rotates and carries the clinker, which drops into it, to its lower end.

The heat abstracted from the clinker is used to dry the coal-dust before it is blown into the kiln.

During the grinding process, 2% of gypsum is added to slow down the setting qualities of the cement.

In both works the Bates American system of filling sacks has been adopted.

The cement is forced into the sacks by air pressure ; while filling they are hung from the arm of a balance and when the correct weight is reached the sack is automatically released, this action also cutting off the supply of cement to it.

As regards the tests applied to the cement, these are well beyond the British Standard Specification in every particular, and it is suggested that the specification may now be due for revision.

The compression tester at Earle's works is very complete, the pressure being gradually increased by electrically-driven pumps actuating on oil columns. The compression tester at the Humber works was operated by a hand-wheel, but did not register to the figure required for testing to destruction in every case.

Some tests of cement were witnessed as follows :—

*Compression Tests.*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 28 | days, | neat cement | ... | 34 | tons on | $2\frac{3}{4}$ | in. | cube |
| 28 | ,, | 3 sand, 1 cement | ... | 28 | ,, | ,, | ,, | ,, |
| 28 | ,, | ,, ,, | ... | 26 | ,, | ,, | ,, | ,, |
| 7 | ,, | ,, ,, | ... | 23 | ,, | ,, | ,, | ,, |

*Tensile Tests.*

| | | | | | | B.S. Spec. |
|---|---|---|---|---|---|---|
| 28 | days, | neat cement | ... | 980 | lbs. per sq. in. | [538] |
| 28 | ,, | 3 sand, 1 cement | ... | 730 | ,, ,, ,, | [250] |
| 7 | ,, | neat cement | ... | 830 | ,, ,, ,, | [450] |
| 7 | ,, | 3 sand, 1 cement | ... | 600 | ,, ,, ,, | [200] |
| 7 | ,, | 3 sand, 1 cement | ... | 690 | ,, ,, ,, | [200] |

The Le Chatelier expansion test is used ; in this test the cement is set in a short split tube, and to each side of the split a long pointer is attached to exaggerate the opening of the tube as the cement sets.

The tester is placed on a glass plate and filled with the sample to be tested ; after 24 hours it is boiled for four hours to thoroughly set it, and the pointers should then not have opened more than 10 millimetres to be up to Brit. Standard Spec. ; actually, in these cements the opening only amounts to one or two millimetres.

The Vicat setting test is also used ; in this test a sharp pointer is

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dropped from a height and the depth of penetration into the sample is measured. In this test also the cement proves well above standard.

As regards fineness of grinding, the residue on a 180 × 180 mesh sieve (*i.e.*, 32,000 holes per sq. in.) is 2 to 4 per cent., while the B.S.S. requirement allows as much as 14 per cent.

## 6. "CONTINUOUS FILTRATION OF THE BATH-WATER OF SWIMMING-BATHS."

*By* T. THOMAS (Hull.)*

The author described chiefly the Hull experience of the filtration of swimming-bath water, where, during the last ten years, three continuous filtration plants have been installed. Adoption of continuous filtration has been slow in this country, though successful plants have been in use here for twenty years. Without such a system, water must be changed every day, or every three or four days, whereas when continuous filtration and sterilization by mechanical and chemical means are used, the same water may be in use during the whole of the swimming season of six or seven months.

A Paper read in 1908 by Mr. Robert Angel described the units of the plant at Bermondsey as follows :—

1. Strainer to intercept particles likely to obstruct the pumps.
2. Two steam pumps to deliver the water to the aerator.
3. An aerator to oxygenate the water, situate on the roof of the baths.
4. A filter, provided with the means of cleansing.
5. A heat condenser, capable of raising the water from 50° to 70° Fahr.

The two most notable changes made in present-day plants are the substitution of an electrically-driven air compressor, fixed in the filtration chamber for the cascade form of aerator on the roof, and that of electrically-driven centrifugal pumps for the steam-pumps. The Beverley Road bath installation is described in this Report.

The author of the Paper gave some particulars of this very up-to-date installation. Samples of the water in the Beverley Road Baths were taken for analysis in 1922, after the water had been in continuous use for 6½ months, and after 33,000 admissions of men and youths, and showed that the water was highly satisfactory, the figures generally showing a standard of purity which is not exceeded by many supplies used for drinking purposes.

The author stated that the estimated annual saving by this method in coal and water amounted to £457 at the East Hull Baths, *less* the filtration plant expenses, £302, giving a total of £155.

* See also Section 7.

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It was admitted that, in conjunction with the filtration plant, slight chlorination must be used.

The filter is the most important unit; the best filter obtainable will be the cheapest in the long run.

In the selection of the filter the following points must be considered :—

1. Filters built up of flat-ribbed cast-iron plates can be easily handled through corridors, doorways, etc.
2. Filters should be of ample area, the flow of water should not exceed 180 to 200 gallons per sq. ft. per hour of filter bed.
3. Apparatus for agitating filtering material at intervals should be provided.
4. Filters should be provided with pipes of ample area for reversing the flow of water through them for cleaning.
5. Water-gauges should be provided to indicate the level of the water during cleansing of the filters, and a mercury differential gauge to indicate the pressure. This also shows when it is necessary to cleanse the filters.

### 7. Visit to Beverley Road Swimming-Baths.

These baths were erected in 1905, the contract price was £25,000, the cost worked out at 7½d. a cubic foot, although the average price of such baths was then said to be 1s. a cubic foot. The area of the site is approximately 4,500 yards super, of which 3,200 yards super have been used for buildings.

The accommodation is as follows :—

Men's swimming-bath 100 ft. by 35 ft.
Boys' ,, ,, 60 ,, 40 ,,
Ladies' ,, ,, 65 ,, 34 ,,
Slipper-baths, 48, enamelled porcelain, hot and cold water.

Shower-baths for washing before entering the water are also provided.

Besides this there is a boiler-house, cycle-store, laundry, small staff room and committee room, waiting-hall and refreshment buffet, all on the ground floor. On the first floor are the manager's apartments.

A feature of these baths is that they may be used during the winter as a dancing hall, concert hall, etc. For this purpose a portable floor is placed over the water space, supported by the margins, the dressing-berths being all made collapsible. The gallery is formed of steel girders and concrete.

Floors are of mosaic; the marble mosaic has been found to be slippery to bare feet, so the gangways have been paved with Burt's

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vitreous mosaic, except in the boys' bath, where a special form of marble mosaic has been introduced. Lighting is electric, with gas emergency pilot lights.

Ventilation is obtained by means of Boyle's air-pump ventilators at the roofs, with suitable low-level inlets.

Heating, both of the building and the water, is by three boilers, which may be used either as steam boilers or simply as water heaters. The method of heating water for slipper-baths is peculiar. In its simplest form, the town water is supplied to a tank on the roof and passes from this tank and through the boilers direct to the baths.

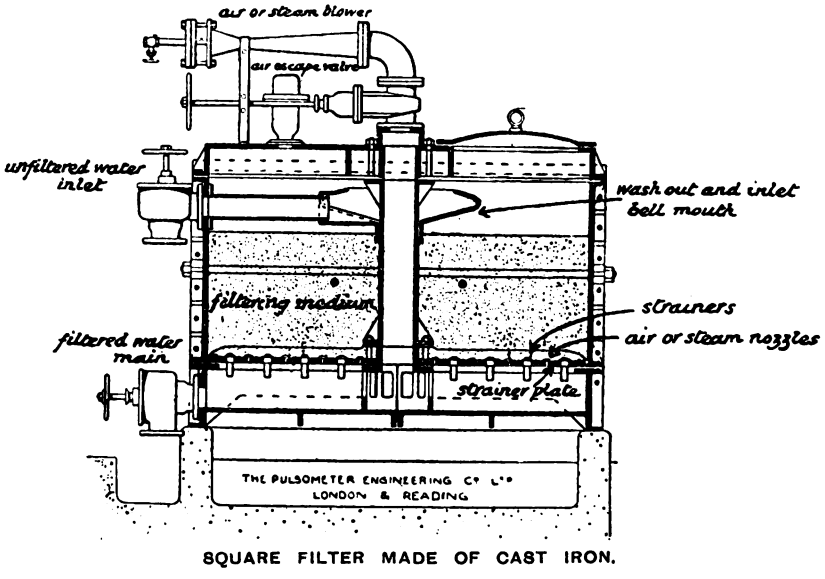
The fuel consumption is rather over half that of more modern systems.

For heating the swimming-baths when filling, two boilers first supply hot water, the third boiler then passes steam through an injector which draws water from the deep end of the bath, and returns it at the shallow end; when the bath is filled, the temperature is maintained in this way.

*Continuous Filtration* (see *Fig.* 1.)

The "Torrent" patent filter, supplied by the Pulsometer Engineering Co., is used. The method of filtration is the usual one, namely, that of passing the water through a certain thickness of suitable filtering medium. Three filters are used.

The excellence of the system lies in the method of cleansing the filtering medium. This must be cleansed throughout its whole thickness; even if a small portion is left undisturbed it becomes a centre of contamination.




SQUARE FILTER MADE OF CAST IRON.

FIG. 1.—"Torrent" Filter.

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These particular filters are square, constructed of cast-iron plates bolted together. A strainer plate is fixed near the bottom of the filter casing, and this plate carries a layer of filtering medium, the lower two-thirds of this medium consisting of crushed granite, the upper third of Leighton Buzzard sand. The total depth is about 2 ft. The bottom of the filter casing is connected to the filtered water main.

The efficiency of the filtration does not depend so much on the thickness and nature of the filter bed as on the thin film of slimy matter which forms on the upper surface of the filtering medium. It is therefore necessary when starting the filter for the first time, or when re-starting it after cleaning, that the filtered water should be allowed to run to waste for a short time to enable the surface of the filter bed to get into condition before the water passes into the filtered water main again.

The cleansing of the filter is effected by reversing the flow; clean water is forced upwards through the filtering medium by means of an electrically-driven centrifugal pump. The process takes about 10 to 20 minutes. Occasionally the filtering medium is further cleansed by forcing steam through it from below. Special brass nozzles fixed in the strainer plate were designed for this purpose, in order that the issuing steam may not pass through the medium by the shortest path but be equally distributed throughout the whole filter. This process is kept on only for a minute or two; the reverse flow of cleansing water may be in action at the same time if required. The capacity of each filter is about 5000 gallons per hour. A certain degree of chlorination of the filtered water is carried out in addition to the filtration, and it is said that it is due to the proper combination of these systems that such successful results have been achieved.

About 3 lbs. of chloride of lime is dropped on to the water all along the side of the men's swimming-bath every evening, and on one evening a week 7 lbs. is used. About 0·5 available chlorine per million by weight is recommended.

The water is aerated as it enters the bath at the deep end by blowing air through with it.

The same water is used in the bath throughout the season. It was seen after four months' use and it then appeared to be quite a clear water.

## 8. Presidential Address to the Engineering and Architecture Section.

*By* Alderman W. C. Fenton, F.R.I.B.A., The Right Hon. The Lord Mayor of Sheffield.

The President referred to road construction by clinker-asphalt which has been found to be very satisfactory in the Sheffield district.

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On sewage a point of interest was his mention of the pumping of effluent for condensation water.

The address again pointed out the necessity of personal hygiene being a necessary factor behind all public works.

The use of ferro-concrete construction for ordinary buildings, as well as for engineering structures, was much to be encouraged.

He had used ferro-concrete, combined with brick and stone, for ornamentation, and considered it an eminently sanitary form of building, having no hollow spaces for vermin, and being very weather-proof.

9. "REINFORCED CONCRETE IN MUNICIPAL ENGINEERING WORKS."

*By* G. W. PALETHORPE, M.C., A.M.I.C.E. (Hull.)

This paper was of considerable interest, and much of it is here reproduced, except that some descriptions of ferro-concrete works executed in Hull are omitted.

Some of the advantages of the use of reinforced concrete are as follows :—

1. Much of it is done by unskilled labour.
2. It increases in strength with age, is practically indestructible, requires no painting maintenance, and is easily repaired where damaged.
3. It is practically fireproof, one inch of concrete being sufficient to protect the steel from fire.
4. Being monolithic, it resists vibration, and is therefore useful for engine-houses, mills and factories.
5. Most of the beams and slabs may be considered as fixed or partially fixed, with consequent reduction of bending moments.
6. It is more adaptable than any other material to alteration to meet unforeseen circumstances.
7. Its cost generally compares favourably with that of brick or steel construction ; the saving in first cost may be as much as 30 per cent.
8. It possesses great possibilities for architectural treatment, though successful instances are rare.

Some of the disadvantages of reinforced concrete are :—

1. The weight of a reinforced structure is more than a steel-framed one, and so requires more expensive foundations ; on the other hand, it is considerably lighter than brick construction.
2. The time for construction is longer than for steel.
3. Owing to the time concrete requires to set, it is impossible to have a structure ready for use under a considerable period.

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The following notes are given upon the construction of reinforced concrete :—

1. A good line foreman is required who will conscientiously see all details of the work carried out.
2. The steel should have an ultimate tensile strength of 28 to 33 tons per sq. in., and comply with Brit. Standard Spec. for structural steel for bridges. The steel should not be oiled, tarred, or painted, but all loose scale or rust must be removed.
3. Accurate placing of the steel is essential. Supports of beam rods from the bottom of the shielding may be by pre-cast cubes of concrete, which can remain in the work.
4. If pre-cast beams are used, the top side must be distinctly marked, to avoid the risk of putting in beams upside down.
5. Shielding must be substantially and accurately constructed.
6. Long beams should be framed with a camber of about 1/350 span.
7. Column boxes should be built up on three sides, and the fourth side should be gradually built up as the concrete is placed.
8. All shielding for beams should be held in position by means of wedges, so that any movement can be taken up.

   The sides of beam boxes should be capable of being removed from the bottom timber to allow air to get to the concrete before the beam is finally stripped.
9. Use few nails for shielding; it is the most expensive part of the work and must be used again.
10. Immediately before placing the concrete, the shielding should be carefully cleaned out, trued up and coated with soft soap, form oil, whitewash, or some other preparation to facilitate removal of the shielding.
11. The aggregate may be of almost any hard, clean material, such as granite, shingle, stone, gravel, or broken brick, but for reinforced work granite or shingle are the best.

    Concrete should always be proportioned so that the sand and cement are respectively in excess of the voids in the aggregate and sand. The percentage of voids in the aggregate is usually about 40 to 50, in sand about 35; 4-2-1 concrete will generally give the best mixture.

    The aggregate should vary in size from $\frac{1}{4}$ in. to $\frac{3}{4}$ in., and the sand up to $\frac{1}{4}$ in., and 75 per cent. of the sand should pass through $\frac{1}{8}$-in. square mesh.
12. The amount of water used is of great importance; the mixture should quake slightly when rammed. The wet mixture will only yield about two-thirds of the combined volumes of the dry materials.
13. The cement should be slow setting, B.S. Specification.

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14. The concrete must be well mixed; if possible, use a mixing machine; it must be laid quickly in small quantities and be well rammed round all rods.
15. Each section of concreting should, as far as possible, be done in one operation.

    When work is resumed upon any concrete that has set, the face should be roughened, washed clean, and covered with a layer of cement mortar. The new concrete should then be rammed against the old as hard as possible without injuring it.
16. Care must be taken to avoid disturbing the set of the concrete; no load, such as walking over it or laying planks on it, should be allowed.
17. Reinforcement rods must not be moved in ramming. New concrete must not be laid in the vicinity of vibrating steelwork, which might affect the setting.

    Concrete must be kept moist and covered up in hot weather, and be protected from frost in cold weather.
18. The time for stripping the shielding must be left to those in charge of the work; it varies from 14 to 82 days.
19. Patent water-proofing compounds may cause a loss of strength, 5 per cent. of hydrated lime added to the weight of cement is recommended by some authorities as quite effective.

## 10. "Some Modern Materials and Methods of Construction for Use in Buildings."

*By* H. D. Searles-Wood, F.R.I.B.A.

A large part of this paper dealt with the use recommended by the author of sand-lime bricks.

These bricks consist of sand and hydrated lime mechanically pressed together and combined under the action of steam pressure. The general size of the bricks is the R.I.B.A. standard—not more than 9 in. × 4$\frac{3}{8}$ in. × 2$\frac{3}{16}$ in., and not less than 8$\frac{7}{8}$ in. × 4$\frac{5}{16}$ in. × 2$\frac{5}{8}$ in.

The fineness of sand used is that which shall all pass a 2,500 mesh per sq. in. sieve and about 85 per cent. retained on a sieve having 10,000 holes per sq. in.

The most suitable lime is a high calcium lime, containing 90 to 95 per cent. calcium oxide, and not more than 0·5 per cent. of magnesium oxide.

The average crushing strength of the bricks when dry shall be not less than the following:—

| | |
|---|---|
| Engineering bricks ... ... ... | 2800 lbs. per sq. in. |
| Bricks for external work ... ... | 2000 ,, ,, ,, |
| Bricks for internal work ... ... | 1000 ,, ,, ,, |

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Hollocrete floors, which are made of pre-cast reinforced concrete beams, formed around a perforated metal hollow core, which is left permanently embedded, were much recommended by the author.

Another interesting construction dealt with in the paper was the Stanton-Hume cast-iron and concrete pipe made by centrifugal action.

A water-jacketted cast-iron mould, lying on a slightly inclined bed, is revolved at a high speed.

Into this mould is discharged the exact quantity of molten metal for one pipe.

A small core is used in the lower end to form the socket.

The iron rapidly solidifies and the pipe is almost immediately drawn out of the mould from the socket end and passed into an annealing furnace.

After passing out of the annealing chamber, the sand core of the socket is removed and the pipes are then tested up to 600 lbs. each. The thickness of the pipe for similar pressure is about 25 per cent. less than would be the case in ordinary vertically cast pipes. The metal produced in this way is extraordinarily dense, its tensile strength varies between 18 to 20 tons per sq. in. After test, a wrought-iron band is shrunk on to the spigot-end to form a bead.

The lining of the pipes with cement mortar, 2 sand to 1 cement, is also done by means of the centrifugal process; after which they are placed in a steam-bath to allow the cement to rapidly harden.

Reinforced concrete pipes are manufactured by the same method. A thin sheet-iron mould is built up, inside which a spiral reinforcement is fixed. These pipes are tested up to 150 lbs. per sq. in. The centrifugal method drives off the water, which prevents later porosity due to water evaporation. The pipes are seasoned for four weeks. A further advantage of the Stanton-Hume pipe is the smooth internal surface produced.

Tests of these concrete pipes have shown them to be capable of withstanding a much greater breaking load than stoneware pipes, something of the order of a 5 to 3 ratio.

The new regulations as to the use of white-lead paint were cited, the most important being that which prohibits dry rubbing down.

The connections and joints of concrete pipes are the great obstacle to their more general use.

Lining iron pipes with concrete was much recommended as an excellent preservative. The use of the correct amount of water in concrete was again urged, an excess of 10 per cent. was said to weaken the concrete as much as 50 per cent.

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11. "THE HYGIENIC ASPECT OF ELECTRICITY IN THE HOME."

*By* Lieut.-Colonel W. A. VIGNOLES, D.S.O., M.I.E.E. [Grimsby].

The author, while referring to the general uses of electricity in the house, and the fact that as an illuminant electric light was pre-eminent, said that, owing to the absence of dirt with this illuminant, the paint and other decorations could be of a lighter colour.

Also that rooms could be lower, with a consequent increase of floor space, if the cubic contents were to remain the same. The lightening of the domestic burden effected by using electricity for ironing and washing was dwelt on.

The domestic vacuum-cleaner was instanced as being the only reasonable system for removing dust from the house; sweeping only stirs up more dust.

The author pointed out that, though electric heating was costly, it must be remembered that the whole of the heat is utilized, no flue being necessary.

He advocated, in a small house, the use of one coal fire, which can be arranged so as to provide the necessary hot water during the winter months, and then to use electricity for the occasional heating required in other rooms, and for providing hot water during summer-time.

The necessity for radiant heat and not only temperature rise was pointed out; electric radiators can supply this want.

Great advances have been made in electric cookers; it is now possible to hire out cookers at rentals of about 10s. a quarter, and, with electricity at a price of 1½d. a unit downwards, electric cooking becomes a serious practical proposition.

It is generally considered that for a household of four, 28 to 30 units of electricity per week would be consumed, if all the cooking were done electrically. At 1¼d. a unit, this would work out at 3s. 1½d. a week.

Houses designed for electric cooking require no flues, a saving in construction.

The actual operation of cooking, whether grilling or roasting, is better done by electricity than by other means. As the temperature can be scientifically regulated as each stage of cooking is reached, this leads to less loss of weight in the meat.

12. "HOT WATER SUPPLY AND SLUDGE DISPOSAL."

*By* A. J. MARTIN, M.I.C.E., F.G.S.

The author outlined methods by which the calorific value of sludge could be utilized for heating water.

The disposal of the sludge being the chief difficulty in sewage disposal, and the supply of hot water to scattered houses being another difficult and expensive problem, it is proposed to utilize the former to supply the latter want. Samples of Birmingham sludge,

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dried at 212° Fahr., gave calorific values of 4,120 and 4,893 B.Th.U. per lb. respectively, or one-third that of coal.

Frankfurt sludge, air-dried to 10 per cent. of moisture, gave an effective calorific value of 4,500 B.Th.U. per lb.

Sludge was used in Lancashire boilers at Birmingham during recent coal strikes. It was found, generally speaking, that 1 lb. of sludge would raise 1 lb. of steam.

Sludge has also been used for production of gas for lighting and for gas-engines.

At Chorley it was carbonized in retorts for producing gas for lighting, 7000 cub. ft. of 20 c.p. gas was the yield per ton of sludge.

Gas may also be produced by the spontaneous decompositions of the sludge by the agency of anærobic bacteria, as at Matunga (near Bombay), where it is used for lighting and cooking.

The composition of the gases from sludge varies very much, but generally they are composed of methane about 65%, carbonic acid about 31%, a little nitrogen and practically no oxygen or hydrogen.

The gas from septic tanks is not liberated continuously, it breaks away from the sludge at intervals, so that tests of yield over short periods are of little value.

At Manchester, the yield obtained was 1 cub. ft. of gas per 100 gallons of sewage, or 0·61 cub. ft. per head per day.

The yield at Exeter was estimated at 1 cub. ft. per head per day.

The digestion of the sludge for gas generation is best done in independent tanks, as at Birmingham and other places, and not in the septic tanks themselves; the evolution of gas is not conducive to a clear effluent. The calorific value of the gas from sludge is estimated generally at 650 to 700 B.Th.U. per cub. ft.

The Gas Light and Coke Co. of London is selling gas of 500 B.Th.U. at 9·2d. per therm, or 3s. 10d. per 1000 cub. ft., so that the value of this sludge gas is considerable for the population of a town.

Passing on to the question of supply of hot water to houses by means of this fuel, the author recommended piping the gas to each house, or possibly to a centrally situated block of baths and wash-houses.

Considering the question as to whether an adequate hot water supply could be provided by means of this sludge gas, the author quoted Dr. Herzfeld as having estimated that the average daily consumption of hot water by a family of five, with the usual number of servants in a house rented at £140 per annum, was 80 gallons at a temperature of 140° Fahr., the cold water being supplied at an average temperature of 54° Fahr., say, 10 gallons per head per day. Geyser efficiency was taken as 75%. Taking these figures as a basis, a household of five would need 88 cub. ft. of gas; and 50,000 cub. ft. of gas, produced each day by the sludge of 50,000 people, would heat the water for 570 houses.

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It was pointed out by the author that the gas is highly explosive, so that there may be an element of risk in its use, but means could be devised for its safe use.

### 13. "PERCOLATION IN CHALK."

*By* G. F. CARTER, M.I C.E. (Croydon).

This Paper contained useful information on the London chalk basin and contained tables showing the rainfall, evaporation, and chalk percolation as taken by Baldwin Latham's gauges.

The Tables covered the years 1918 to 1922 month by month.

A remarkable figure occurs for July 1920, when the rainfall was 4·84 inches, the highest shown for any month in the Tables, the evaportion was 2·25 inches, whilst the percolation was zero.

For eight consecutive months in 1921, the percolation was zero, but the rainfall was then ranging from 0·17 to 1·99 inches only.

### 14. "DUST LAYING BY AN EMULSION OF OIL AND BITUMEN."

*By* Major-General Sir GEORGE K. SCOTT-MONCRIEFF, K.C.B., K.C.M.G., C.I.E., HON. M.I.C.E.

This Paper, in addition to the laying of dust on roads, dealt with the treatment of dust in mines, the successful laying of which would, the author pointed out, alleviate to a great extent the hard lot of the miner's life.

Much of a satisfactory nature has been done already towards this end, and further experiments are now under preparation, aiming at the prevention of explosions, together with their transmission by dust.

Dust, usually created by some of the processes of civilized life, is characterized by want of cohesion between the particles, and increased area of surface tension.

It is in some cases of a combustible character and a fruitful cause of explosion in mines, etc., and also a danger to health.

The remedy usually adopted of treating the dust with water is unsatisfactory because of rapid evaporation, and in mines this remedy is not always permissible because of the condition of the natural strata.

The ideal liquid in mines is one which contains a small quantity of solvent and has a low surface tension.

For work on roads a binding element is necessary to provide cohesion in the dust, and this binding element is found in bitumen, which is capable of being melted into a liquid form, and under certain mechanical treatment can combine with oil to form an emulsion.

Thus, there are three elements involved in the emulsion, *i.e.*, water to act as a conveyer, oil to act as a lubricator, and transmitter of interfacial energy, and bitumen as a binding element.

An emulsion sufficiently stable to be transmitted from the place

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of manufacture to the place of application, and then locally diluted with water, has been found effective; the proportions at present used are 50% water, 15% bitumen, 35% oil.

In municipalities the use of the emulsion has been found to result in great saving of water for keeping down dust in streets, and on country roads the emulsion, mixed with 9 or 10 times its volume of water and sprinkled by a water-cart in the ordinary way, has been found remarkably effective.

The further application of the principle to factories, shops, refuse heaps and so on, has not yet been extensively tried, but there is little doubt that it will be found to be as efficacious as in the case of roads and mines.

### 15. "Pure Water Supplies."

*Lecture by* Sir Alexander Houston, K.B.E., C.V.O., M.B., D.Sc.

This lecture dealt firstly with the general water supplies of England :—

The cities and towns of Lancashire and Yorkshire, drawing their supplies from upland and moorland sources.

The deep-well and spring supplies of other places such as Sunderland, Scarborough, Hull, Lincoln, Cambridge, Canterbury, Hastings, Bristol, Lancaster and many others.

The purified water supplies of such places as Reading, Gloucester, Cheltenham, Plymouth, Exeter, Worcester, Northampton, Bedford, Chester and York. The London water supply was dealt with separately.

The author said that England has every reason to be proud of the quality of water supplied to her consumers. He said that we stand as pioneers in all matters that really count in the matter of water purification, for example :—

(*a*) Slow sand filtration.
(*b*) Storage.
(*c*) Lime softening and purification.
(*d*) Excess lime sterilization.
(*e*) Chlorination.

Of the London daily water supply of 250 million gallons, about 60% is derived from the river Thames, 20% from the river Lea and 20% from deep wells. It is interesting to note that the total volume of well-water is not all supplied direct to consumers; over a quarter of it is pumped into the river Lea or New River, mixed with the river water and subsequently filtered. The method of treating the well-water from the Deptford (Twins) Well, which fell off considerably in quality during the drought of 1921, is as follows :—

Briefly stated, the process is one of adding considerably more chlorine to the water than is actually needed for sterilization purposes and then removing the excess of chlorine by means of a

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solution of sulphurous acid gas. In this way all taste troubles have been eliminated, and there can be no doubt that super-chlorination and de-chlorination methods, although about doubling the cost of the treatment, entirely remove the possibility of taste.

A reason, not known to all, for the immense power of recuperation of purity of the river Thames, was explained in that there are really two Thames rivers, the surface one and an underground one of vastly greater volume which contributes all the way down to the replenishment of the former, with exceptionally pure water, being automatically filtered in the process.

The New River supply was explained as an interesting example of a chlorination difficulty successfully overcome. This river is really part of the water of the Upper Lea diverted along an artificial channel nearly 30 miles in length.

Chlorination was tried, but although successful from a bacteriological point of view, the most serious taste troubles were experienced. At times the New River is intensely susceptible to chlorine taste troubles; the filter beds tend to absorb the taste-imparting materials, to store them up for a certain period, and then allow them to escape into the filtered water.

After much anxious thought the problem was finally solved by skilfully adapting the dose to the current quality of the river water and the supplemental use occasionally of permanganate of potassium (a great taste preventer or remover).

One other trouble that occurs is growths in the spring which might lead to filtration trouble, though harmless otherwise. Considerable success has been achieved by treating the reservoir water with such algicidal agents as chlorine or copper sulphate, a quite harmless procedure if carried out under suitable supervision. Rapid filters have the power of holding back these growths and are worthy of extended trial. They are now being tested on a practical scale at the Barn Elms, West Middlesex Works.

The river Lea supply is purified by storage and slow sand filtration.

The author enlarged on the value of storage as a means of purification. He said it was Nature's own method of purification. In the first place, most of the solid impurities in the river water are settled out (sedimentation); secondly, any sudden chance pollutions of a dangerous character are enormously diluted (equalization); and finally, any pathogenic bacteria present gradually lose their vitality and die during the passage of the water through these enormous reservoirs (devitalization).

Speaking of the Thames chlorination treatment, the author said that so long as the cost of chlorine for sterilization falls far short of the cost of coal for pumping, it is likely to be continued indefinitely.

There is little doubt that Thames water is more easily treated by chlorination than New River water.

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The dose of chlorine is very small, on the average appreciably less than 1 in 2 millions, yet it has a power of improving the water bacteriologically about a thousand times. The Thames and New River chlorination problems are diametrically opposed in principle. In the latter case, the results are so good during the three-quarters of a year that no treatment is necessary, and chlorination is only practised during the flood months of the year.

As regards the Thames, it is a case of saving pumping charges during dry weather by means of chlorination and reverting to the use of adequately stored water when the Thames is in high flood.

It was noticed in the lantern slides shown that the Paterson Chloronome (see Section 17) is used.

## EXHIBITS AT THE HEALTH EXHIBITION.

### 16. Sack Disinfector.

*(Meldrums, Ltd., Timperley, Manchester.)*

This apparatus consists of a suspended inverted sack, 2 ft. in diameter by 4¼ ft. long, into the top of which steam is introduced through a flexible tubing from a boot boiler heated by a pressure oil lamp or other means. The weight of the complete apparatus is 125 lbs. The steam descends through clothing hung up in the sack expelling equivalent air from its mouth.

The latent heat makes the articles so intensely hot that they dry immediately on removal from the sack.

After steam begins to emerge from the sack mouth, continuance of steaming for :

(*a*) One minute kills all non-spored pathogenic organisms, vermin and eggs.

(*b*) Five and a half minutes destroys anthrax spores, even if enclosed in plugged test-tubes embedded at the centre of a drum of textiles.

The capacity is :—

150 lbs. of textiles in ¼ hour.

(*a*) *Close-packed Charge.*—120 single blankets in one hour.

(*b*) *Suspended Charge.*—6 suits of clothes in five minutes.

Fuel consumption is 6 pints of oil an hour or 9 lbs. of coal an hour.

It is estimated that one set per 1000 soldiers is sufficient for disinfection of bedding and clothing.

The complete set can be carried on a push bicycle.

*Remarks.*

The American Army has adopted the use of this apparatus. The system seems to be simple, effective and presumably economical where large-scale plant is not available.

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## 17. WATER DISINFECTION. "PATERSON CHLORONOME."

*(Paterson Engineering Co., Kingsway, W.C.2.)*

The chloronome is a device for regulating, measuring and administering chlorine gas to water supplies for their sterilization. The direct use of the gaseous chlorine in place of the usual hypochlorite of lime has many advantages. Hypochlorite is an unstable reagent, of which only $33\frac{1}{3}$ per cent. of chlorine is available under the best conditions, which vary according to climate, and the preparation of pastes and solutions is laborious; whereas, when the gas is applied direct, the quantity administered can be adjusted with scientific accuracy.

The chloronome consists essentially of means for conducting the gas from the cylinders, in which it is stored under pressure as liquid chlorine, to the water to be treated. The gas pressure has to be reduced in the process to a constant low pressure, and an exact measurement of the gas passing has to be made.

There are two types of chloronome, the Pulser type and the Manometer type. *Fig.* 2 shows the Pulser type. This is capable of administering 10 lbs. of chlorine per day and sterilizing a maximum of one to three million gallons of water daily. The cylinders of liquid chlorine hold about 70 lbs. each, the pressure at 32° Fahr. being 54 lbs. per sq. in., and at 120° Fahr., 215 lbs. per sq. in. The chlorine passes into the gaseous form on evaporation by the heat abstracted from the atmosphere through the walls of the cylinders.

The gas is first led to a filter, which removes any slight deposit which may be carried by the gas from the exposed coil tubes or the cylinder fittings. After this, two pressure-reducing valves are arranged in series. The gas, at a pressure varying from 80 to 120 lbs. per sq. in., passes through the first reducing-valve, which breaks down the pressure to 20 lbs. per sq. in., then through the second reducing-valve which maintains a constant pressure of 10 lbs. per sq. in. on the regulating valve.

The chlorine gas then passes the regulating valve and flows from the meter (detailed reference to which is made later) through a central pipe down to nearly the bottom of the absorption tower.

This glazed earthenware tower is fitted at the top with a water-distributing tray, and packed with pumice.

A small trickle of water is uniformly distributed over the pumice, and in its downward flow absorbs the measured quantity of chlorine gas.

The chlorinated water flows from the bottom of the tower through a chlorine-resisting rubber or earthenware pipe, and is uniformly distributed through the main body of the water to be disinfected. Many water supplies can be chlorinated by the addition of a quarter part per million, *i.e.*, 2·5 lbs. of chlorine gas per million gallons of water purified, so that an installation purifying 1,000,000 gallons

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per day may only require to administer 1·66 oz. of chlorine per hour. A positive volumetric measurement of gas administered is therefore

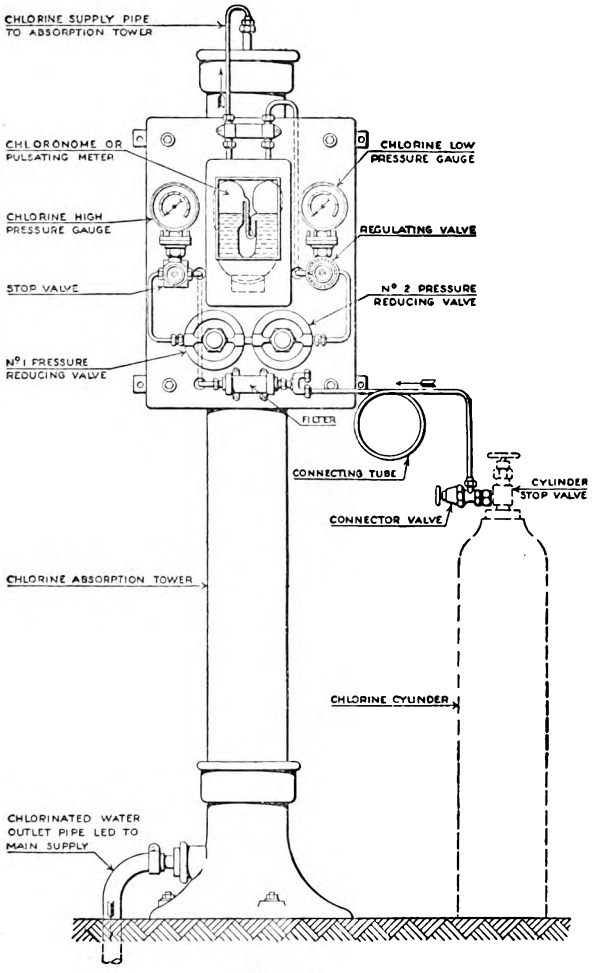


FIG. 2.

desirable. The chloronome pulsing meter consists, essentially, of a U-shaped tube, with a connecting branch between the two limbs (see *Fig.* 3).

The U tube contains sulphuric acid, which acts as an inert seal between the dry chlorine gas in the instrument and the absorbing water supply.

The flow of gas into the inlet limb depresses the column of sulphuric acid until it unseals the small vent pipe, so permitting the passage of the measured quantity of gas from the inlet to the outlet limb; this establishes equilibrium and allows the return of the column of sulphuric acid until it again seals the vent pipe, when a cycle of

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movement is completed and another downward stroke commences. The rate of pulsation and known volume of the stroke gives the weight of chlorine added.

For deliveries exceeding 10 lbs. of chlorine per day, the Manometer type of apparatus is recommended. In this type, the pulsermeter is replaced by a special fitting containing a silver diaphragm plate, having an orifice of predetermined size. A connection from either side of this diaphragm is led to the two limbs of a manometer tube and the difference in pressure set up by the rate of flow of the gas causes a displacement of the liquid contained in the tubes which are graduated to indicate the flow in lbs. per hour.

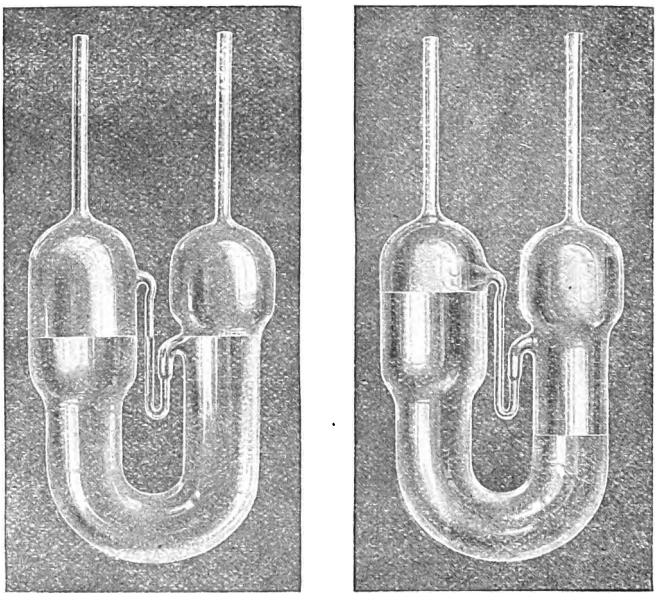

FIG. 3.—Paterson Chloronome Pulser Meter.

For military purposes a portable oufit, comprising a complete pumping, filtering and sterilizing equipment, is fitted on a motor lorry.

The water lifted by a petrol-driven rotary pump, after treatment with a trace of sulphate of alumina to coagulate the suspended impurities, passes into the reaction tank, which allows the bulk of the impurities to be precipitated. A quartz sand filter secures the final purification, and the chloronome administers the correct dose of chlorine to ensure disinfection.

*Remarks.*

The system is of proved utility. It is used by the Metropolitan Water Board, amongst others.

Water chlorination is recognized as the best sterilizer for military purposes, *vide* the Service water-cart; if the precise dose can be

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administered as is done by the chloronome, the system of chlorination of water is raised from a rough process to an exact one, and the risk of over-chlorination may be avoided. Also, the bulky and unstable reagent is replaced by sealed cylinders of liquid gas. There seem to be possibilities of the wide application of this system to military purposes. As far as the portable outfit is concerned, this should prove useful for fairly large forces. The system might be applicable in smaller units also. Some special tests would no doubt be necessary in this case, especially as to the robustness of the sulphuric acid pulser, but the problem does not appear to be insuperable.

18. "LEWBART AUTOMATIC DISINFECTOR AND DEODORIZER."

(*Lewbart Manufacturing Co., Ltd., Norfolk Street, Strand, W.C.2.*)

This is a small instrument, 3½ in. diameter and 8 in. long, clipped on to the flush pipe of a latrine, without severing the pipe or using solder, making a water-tight joint by means of a small rubber pad.

A small square hole (⅝ in. square) is made in the pipe to allow the trigger to be inserted, and a small hole (⅛ in. diameter) to take the discharge of the disinfectant. The action is automatic and foolproof, the descending water actuates the trigger which starts a simple drip-feed, thus releasing a few drops of disinfectant.

The disinfectant enters the pan only after the flush has taken place. The mixture is not further diluted with the water in the pan, but merely floats on the top, and therefore forms a protective barrier.

The container holds sufficient disinfectant for 1,400 pulls of the chain.

*Remarks.*

The fitting is robust, effective and simple, the movements are so loose-fitting that it is difficult to imagine their becoming jammed or stiff through want of use.

If the joint to the pipe remains water-tight, the fitting should give satisfaction and would add considerably to the cleanliness of latrines. A trial in barracks would be inexpensive; the fitting costs 35s. For military purposes it might be found necessary to construct a heavier fitting and to lock the disinfectant container in some way.

19. "PARKS' VALVELESS W.W.P. FLUSHING CISTERN."

(*Arthur Parks, 31, Mount Ephraim, Tunbridge Wells.*)

A ball cock is used, and the dome is lifted by a downward pull on a rod projecting below the cisterns.

This does away with long levers and chains, is very silent, and the cistern can be fixed in any position.

The arrangement is practical and workmanlike and worth attention.

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### 20. "SILENT HARRIAP W.W.P. FLUSHING CISTERN."

*(G. W. Harrison & Co., Napier Lead Works, Laisterdyke, Bradford.)*

The forerunners of this cistern are well known and have an excellent name; this latest pattern is remarkable for its fine single casting of antimonial lead, copper being the only other metal used.

It is a cistern which should require the minimum of upkeep, and is to be used in some of the important building schemes now in hand. The price of a 2-gallon iron cistern would be about 23s.

### 21. "FLAVEL'S 1923 LEAMINGTON GAS-COOKER," AND THE "FLAVEL" BURNER.

*(Sidney Flavel & Co., Leamington.)*

This gas-cooker, which employs the Flavel burner (described later), has several neat and well-arranged devices.

The burner taps are fitted at the front and are protected by a guard-rail; their levers automatically fall to "turn down" should they become loose.

The grilling burner, which is the only non-Flavel burner used, can be rotated through 90 degrees to convert it to a double boiling burner.

The simmering burner is a Flavel burner with an adjustment for raising or lowering its height to the exact amount required for gentle simmering. The oven burner is so arranged that, when turned off, the ventilating flue in the oven is also closed, thus assisting in the retention of heat in the oven.

The Flavel burner itself is an exhibit of considerable interest. The principle is that of the Bunsen burner, with the addition that in this construction the mixture of gas and air circulates in a peculiar spiral motion, which produces perfect combustion on ignition. It burns with an intensely hot flame and has a guaranteed efficiency of 30% greater than the old-type drilled burners. The principle is simple and is well illustrated by *Fig.* 4.

The flame issues in a complete circle of solid flame. The opening from which the flame issues is machined to precise limits, so that there are no variations in the size of the discharge apertures in the burners.

All gas passages are perfectly smooth and free from obstruction, so that there are no pockets to retard gas and create noise in burning. The air trap constitutes an important part of the burner; by depressing the finger plate when lighting or putting out, these operations can be performed silently.

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The mixture can be regulated by the screw shown. The burner was shown in the action of boiling a kettle of water; it was noted that the admission of air to the burner at once increased the volume of steam issuing from the kettle, and closing the air-trap had the reverse effect.

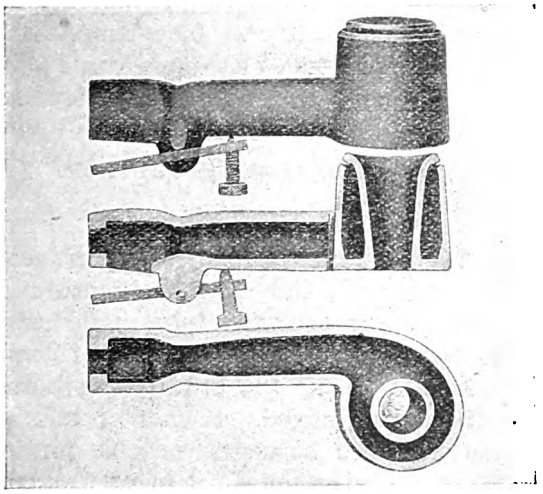

FIG. 4.—"Flavel" Burner.

An independent test in comparison with ordinary drilled burners is said to have resulted as follows:—

*Ordinary Burners*: 2 pints water boiled in 7 minutes, 22 seconds, gas consumption 2·31 cub. ft.

*Flavel Burner*: 2 pints water boiled in 7 minutes, gas consumption 1·48 cub. ft.

### 22. "EASILIT BLOW-LAMP."

("*Easilit Blow-Lamp Co., 34, Watford Road, King's Norton, Birmingham.*)

This lamp, which appears to have already received some attention at the hands of the Service, is in use by the Post Office. It looks like a successful attempt to solve the difficulty of starting up the usual type of blow-lamp.

The features are an additional burner (at right angles to the main burner), the flame from which impinges on a plate which spreads the flame for giving better distribution of heat for vaporization. The necessity for pouring spirit from a separate can into the usual cup-retainer on the lamp is thus done away with.

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The burners are cleaned by automatic cleaning pins, which are inserted through the backs of burners; these pins are drawn inside and away from the flame so that they may not be affected by heat. The usual pricker is therefore not required. The pressure pump is neatly fitted in the handle of the lamp.

The knobs by which the prickers are actuated project somewhat, but do not appear to be unduly fragile; if they are broken off, the lamp can still be used as an ordinary blow-lamp. A branding-iron attachment can be fitted in the blow-lamp flame; this is a great time-saver where numerous articles have to be branded.

### 23. "IVEX DOMESTIC INVERTED BURNER." (*Fig.* 5.)

(*A. E. Podmore & Co., 34, Charles Street, Hatton Garden, E.C.*1.)

This is a superheated burner similar in appearance to the Alrae burner used in the Service, the chief difference being that the pre-heated air is drawn through three tubes, attached to the corona band, from below the outlet of the products of combustion, to a central mixing chamber above the head of the burner where the gas and air are thoroughly mixed. Each air port is provided with an adjusting shutter. The burner is suitable for interchange of nozzle for bijou, medium, or universal mantle and mundus; the same burner can be adapted for using one or three mantles.

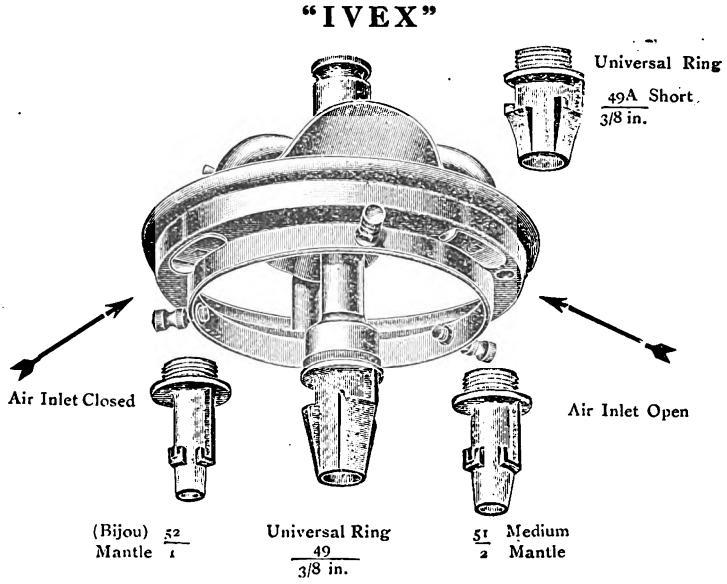


FIG. 5.

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# *ANTI-TANK MINES IN MOBILE WARFARE.*

*By* CAPT. AND BREVET MAJOR R. H. DEWING, D.S.O., M.C., R.E.

THE means of anti-tank defence at the present time comprise artillery, our own tanks, natural obstacles and artificial obstacles. *Engineer Training* specifies anti-tank defence as one of the duties which engineers may be called upon to undertake in the field, and consequently the question of the provision of artificial tank obstacles merits consideration.

Artificial anti-tank obstacles may be divided into :—

(i) Some form of ditch impassable for tanks. If concealed, the ditch develops into a " tank trap."

(ii) Some form of stockade. In order to stop tanks the stockade must be of very strong construction and usually entails heavy concrete work.

(iii) Inundations.

(iv) Land mines.

Of these various forms of obstacle (i) and (ii) both demand either more time, more labour or more transport than would be available in mobile warfare. Inundations are only possible where specially favourable natural conditions exist. Land mines, therefore, remain the only class of tank obstacle which the engineers might generally be able to provide in mobile war.

Very little is at present laid down in our text-books with regard to anti-tank mines. *Tank Training* mentions mine fields as being a source of anxiety to tanks, but gives little further information on the subject. *Military Engineering*, Vol. IV, after saying that anti-tank mines were used in the War of 1914–18, states that the most suitable form of anti-tank mine is now under consideration.

There can be little doubt that, in the event of our being engaged in a war against an enemy armed with tanks, there will be an immediate and insistent demand for every possible form of anti-tank protection. Mines alone can never provide efficient protection, any more than barbed wire alone can be a protection against infantry. The framework of anti-tank defence under present conditions must be anti-tank artillery, but mine fields may prove as important an accessory to these guns as barbed wire has proved to machine-guns.

The question deserves consideration not only from the point of view of our own defence, but also to provide security for our offensive tank forces. It is wrong to think that by exploring possible anti-tank measures we are counteracting the offensive value of our own

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tanks. It is only by foreseeing the probable anti-tank measures which the enemy may employ that our own tanks can be secured against them.

### THE USE OF ANTI-TANK MINES IN THE WAR.

The tank itself was in its infancy at the time of the Armistice. Counter measures to meet any new weapon inevitably follow behind the development of that weapon; and consequently the possible means of anti-tank defence were only explored to a very limited extent during the War.

As we led the way in the development of the tank we might naturally expect to find anti-tank measures developed mainly by the Germans. Actually, they do not appear to have treated the problem seriously until the last five months of the war, when they evinced a feverish activity in seeking counter-measures. Their extreme anxiety on the subject, combined with the rapid development of the final operations of the war, prevented any really effective treatment of the problem.

Anti-tank mines were used both by the Allies and by the Germans. They most usually took the form of shells or trench mortar bombs, provided with a special type of firing mechanism and buried just below ground level. A type of contact-firing mechanism was devised which operated when a tank passed over the mine, but which was not fired by the passage of infantry or transport.

The German mine fields do not appear to have scored any great success against our tanks; in fact, the heaviest recorded allied tank casualties from mines occurred through tanks running over one of our own mine fields laid before our retreat in March, 1918, and forgotten. This disaster occurred at the end of September, 1918. The mine field consisted of rows of buried trench-mortar bombs, each bomb containing 50 lbs. of ammonal. In spite of having been laid seven months previously, the efficacy of the mine field was demonstrated with unfortunate thoroughness. The weight of explosive used was sufficient to blow in the bottom of the machines and cause severe casualties among the crews.

### NEUTRALIZATION OF MINE FIELDS BY THE ENEMY.

As the use of mine fields becomes more general, methods of counteracting them will, in turn, come into prominence.

Three methods of destroying mine fields have been suggested:—

(i) By artillery fire.

(ii) By providing tanks with a roller pushed ahead of the machine in such a way as to detonate mines before the tank itself reaches them.

(iii) By a form of plough pushed ahead of a tank.

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The destruction of mine fields, the exact location of which is unknown, by artillery fire would demand an expenditure of ammunition which is not likely to be possible in mobile warfare.

Though neither the roller nor the plough has yet been perfected as a mine-clearing machine, it may be expected that some form of mechanical mine-sweeper will eventually be evolved.

Such a machine is only a partial answer to the mine; and its use would not completely neutralize the value of the land mine, any more than naval mine-sweepers have been able to eliminate entirely the value of mines at sea. The necessity for every tank formation being preceded by mine-sweeping tanks whenever operating over ground which might be mined, would constitute a handicap upon the manœuvre power of the tanks, which would itself justify the use of the mines.

## The Probable Type of Anti-tank Mine.

For use in mobile warfare it is essential that an anti-tank mine should be light enough to be easily transportable in large numbers. It may be assumed that the use in mobile operations of mines, sufficiently powerful to break through the armour of a tank, and so inflict casualties on its crew, will be precluded by the weight of explosive required. The mines will, therefore, probably be designed to break the tracks of the tank and so render it immobile. For this purpose a mine weighing from 10 to 15 pounds would probably be sufficient.

Other desiderata for the mine are that it should be safe to handle, quick to lay and easy to conceal. There should be no difficulty about ensuring safety in handling. Rapidity in laying and facility in concealing would both be realized by a small mine designed to be laid just under the ground surface, and calling for the minimum of digging. These characteristics do not appear to be difficult to realize.

We may then assume that mines will be available possessing the following characteristics:—

(i) Weight, 10 to 15 lbs.
(ii) Powerful enough to immobilize any tank whose track passes over it.
(iii) Safe to handle.
(iv) Quick to lay and conceal. Say 1 man could lay 1 mine in normal ground in 5 minutes.

From these assumptions we can draw certain data:—

(i) A 3-ton lorry could carry about 400 mines.
(ii) A section of a Field Company, R.E., could lay a field of 500 mines in about 1 hour, presuming the mines are dumped on the site.

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(iii) To form an efficient mine field at least one mine per yard of front to be covered is required. This allows of two rows of mines, with mines 6 ft. apart in each row. It may be found that three rows of mines are desirable, requiring $1\frac{1}{2}$ mines per yard of front.

PRACTICABILITY OF SUPPLY OF MINES IN MOBILE WARFARE.

The use of mines while operations are so mobile that formations are moving daily is clearly neither useful nor practicable. The demand for mines will occur as soon as a formation occupies a position with a view to meeting an enemy attack upon it. It may be anticipated that a period of from 24 to 48 hours may be available in which to put such a position in a state of defence.

The previous operations should have given sufficient indication of the probable course of events to permit a supply of mines being available at railheads very soon after the decision to occupy a position is taken. The problem then becomes one of transport forward from railhead. The establishment of a Div. M.T. Co. includes two 3-ton lorries for R.E. stores, but the demands on these lorries for the carriage of normal R.E. stores would be too great to allow their being used for mines. The best solution of the problem would be the allocation to Divisions of lorries specially for the carriage of anti-tank mines. Until this development takes place transport would have to be found either by the Corps or the Division diverting M.T. from its normal duties, or by utilizing the pontoon trailers of the Field Park Company with the Division, provided that they were temporarily available. These latter have a caryring capacity of 42,000 lbs., say 2,800 mines.

The question of transport forward from railhead is, therefore, in doubt. With our present establishment of M.T. it would usually be possible to make 8 or 10 lorries available if the urgency of the need for anti-tank mines justified it.

If we consider a Division holding a front of 5,000 or 6,000 yards, faced with the probability of attack by an enemy with superior strength in tanks, and relying mainly on the fire of twelve Pack Artillery Howitzers for defence against these tanks, it seems likely that its need of additional anti-tank defence will be urgent enough to ensure transport being found for, say, 3,000 mines.

On the basis of the assumptions made, we may consider that a Division could have sufficient mines to cover about half the frontage it is holding. This quantity of mines could be laid by two Sections of a Field Company R.E. in about four hours; and the mine-fields should easily be completed within twelve hours of the arrival of the mines at railhead.

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## Method of Employing Mines.

*The Value and Limitations of Mine-Fields.*—In considering the method of employing mine-fields, their value and their limitations must be realized. Their value is two-fold :—

(i) Their physical value, arising from their power of rendering tanks immobile.

(ii) Their moral value, arising from the effect on the nerves of the driver of a tank of the knowledge that he may at any moment drive into a mine-field, be put out of action, and remain an easy target for artillery.

The main disadvantage of mines lies in the restriction which they lay upon the movement of our own tanks, and possibly of other troops, in counter-attack.

The mines under consideration also have the limitation that, though they would be capable of stopping a tank, they would not put either its crew or its armament out of action.

*Co-operation.*—In selecting sites for mine-fields it is essential to consider how they may affect or be affected by the action of other arms.

Lines on which it is probable that our own tanks may be required to counter-attack must be left clear.

Areas which are likely to be under heavy concentrations of our own artillery fire in the early stages of an enemy attack are not suitable, owing to the probability of a large proportion of the mines being detonated by that fire.

The mine-fields must be sited in conjunction with the siting of anti-tank guns, and must be within their arc of fire to achieve their full effect, since the mine will only stop the tank and the gun is required to put its armament and crew out of action.

A mine-field should normally be under infantry or machine-gun fire to prevent enemy working parties clearing a path through the field, once they have located it. In order to exploit the moral effect of the mines it may, however, be useful to site a few small mine-fields in defiles well forward of the infantry positions, simply with the object of increasing the uncertainty and limiting the enterprise of the enemy tanks in their advance.

*Influence of Ground.*—On any front there are likely to be certain lines of approach favourable to tanks, and certain sections where woods, marshy ground, streams or railway embankments constitute natural obstacles to tanks.

Mine-fields will naturally only be employed on sections of the front favourable to tanks ; and any defile confining the possible tank routes will be a particularly good site to mine.

On these sections some portions of the ground will probably favour

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concealment of the mine-fields more than others, and this will be a factor in the selection of sites.

There may be covered approaches constituting dead ground which it will be difficult for anti-tank artillery to cover. This may justify the laying of a mine-field which is not covered by the fire of the defence, as an enemy tank disabled in such a site could not use its weapons effectively.

*The Responsibility for Siting Mines-Field.*—The factors affecting the location of mine-fields and the arms affected are so various that it is important that the responsibility for determining their siting should be definite. The final responsibility should rest with the C.C. Infantry Brigade holding any sector; and a sound procedure would be for an R.E. officer to be detailed to carry out reconnaissance on each Brigade front. The Brigadier would lay down the general policy of anti-tank defence at his conference preliminary to the reconnaissance of the position. The R.E. officer would accompany the anti-tank artillery commander on a detailed reconnaissance of the whole Brigade front, on completion of which he would be able to submit a complete plan of proposed mine-fields for the confirmation of the Colonel-Commandant.

It is important that records of mine-fields laid should be kept systematically. The danger of our own tanks suffering from our own mines has already been referred to.

*Use of Mines in Rear of the Main Infantry Zone.*—The foregoing notes have been confined to a consideration of the employment of mines as part of the defences of the main zone held by the infantry, because it seems probable that it is there that their use is likely first to become general. As the powers and range of movement of tanks increase, the problem of providing anti-tank protection for Brigade, Divisional and Corps Headquarters, and important administrative centres in rear of the main zone will become increasingly important.

Anti-tank mines will play their part in these defences no less than in the forward defences.

*Training and Organization.*—The example of the German attempt to improvise anti-tank measures in haste during the last months of the war, should be sufficient to emphasize the importance of organizing any form of such defence during peace, and ensuring that the officers and men concerned are given such training as may be necessary.

The technical training of the R.E. personnel in laying the mines requires very little time; and, once the mines or dummies are available, could be carried out in a few hours.

The training of officers is more important. Officers should know what constitutes a natural tank obstacle, and what does not, as this knowledge must form the basis of any anti-tank defence. They

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should be able to judge whether a railway embankment or cutting is sufficiently steep to prevent the passage of tanks; whether the tree-stumps in an area cleared of wood are high enough to stop tanks; and whether the banks and bottom of a stream permit tanks to ford it.

Sapper officers should know the powers and limitations of the Pack Artillery Howitzer, and Pack Artillery officers should have similar knowledge with regard to mines.

All senior officers and staff officers should have the knowledge required to enable them to co-ordinate the scheme of anti-tank defence on a Brigade front. The transport problems that will crop up as soon as mines are demanded must be realized and considered beforehand if they are to be dealt with effectively in war.

None of this training is difficult. It is only necessary to give these questions consideration whenever troops are being exercised, or schemes and staff rides are being carried out, under conditions which lend themselves to the problem.

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# *STEREOSCOPIC PLOTTING MACHINES FOR USE IN PHOTOGRAPHIC SURVEYING.*

*By* COLONEL H. ST. J. L. WINTERBOTHAM, C.M.G., D.S.O.

FOR the preparation, in war time, of maps of areas into which our surveyors cannot penetrate we must rely upon surveying from air photographs, and it is obvious that there will be no time to waste. We cannot afford to rely, wholly, upon those graphic, optical, and photographic methods which, theoretically sound enough, entail in practice laborious and lengthy personal work. If only the problem is solvable by some swift and reliable automatic machine, not only will the difficulties of war-time mapping be lightened, but surveying from air photographs may force its way to a position of economic equality with the ordinary ground methods.

An individual photograph is a two-dimensional view of a three-dimensional landscape. Whatever we do, therefore, we cannot survey completely anything but a flat plain from it. We must have two views of the same area from different view-points if we want both to map and to contour. If we take each view individually, and separately, we can extract from it nothing but bearings, but if two views of the same area can be examined simultaneously in a stereoscope we secure a three-dimensional image. To make it possible to secure this image, however, we have to place the two views in the same relative position to each other as they actually assumed in the air. This done, we can move them so that the stereoscopic fusion of the twin images of a definite spot occurs at a distance and bearing corresponding to the distance and bearing in nature from the air base. The problem is then to use the movements of the views (negatives, diapositives or prints) relatively to each other and to the observer in such manner as to plot, automatically, the position, and to record the height, of the point we examine in the stereoscope.

It is quite commonly held that stereoscopic fusion is attainable only with acute intersection. The limit, on the analogy of our own ordinary powers, is supposed to be of the order of 16°. Indeed, it is not always easy to persuade experts that fusion can be secured, under normal circumstances, and for small areas, at angles which approach even to the right angle. Such is, however, the case. Being in no sense of the word an expert on these matters, I cannot

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## PRINCIPLE OF THE CAMERA-PLASTICA.

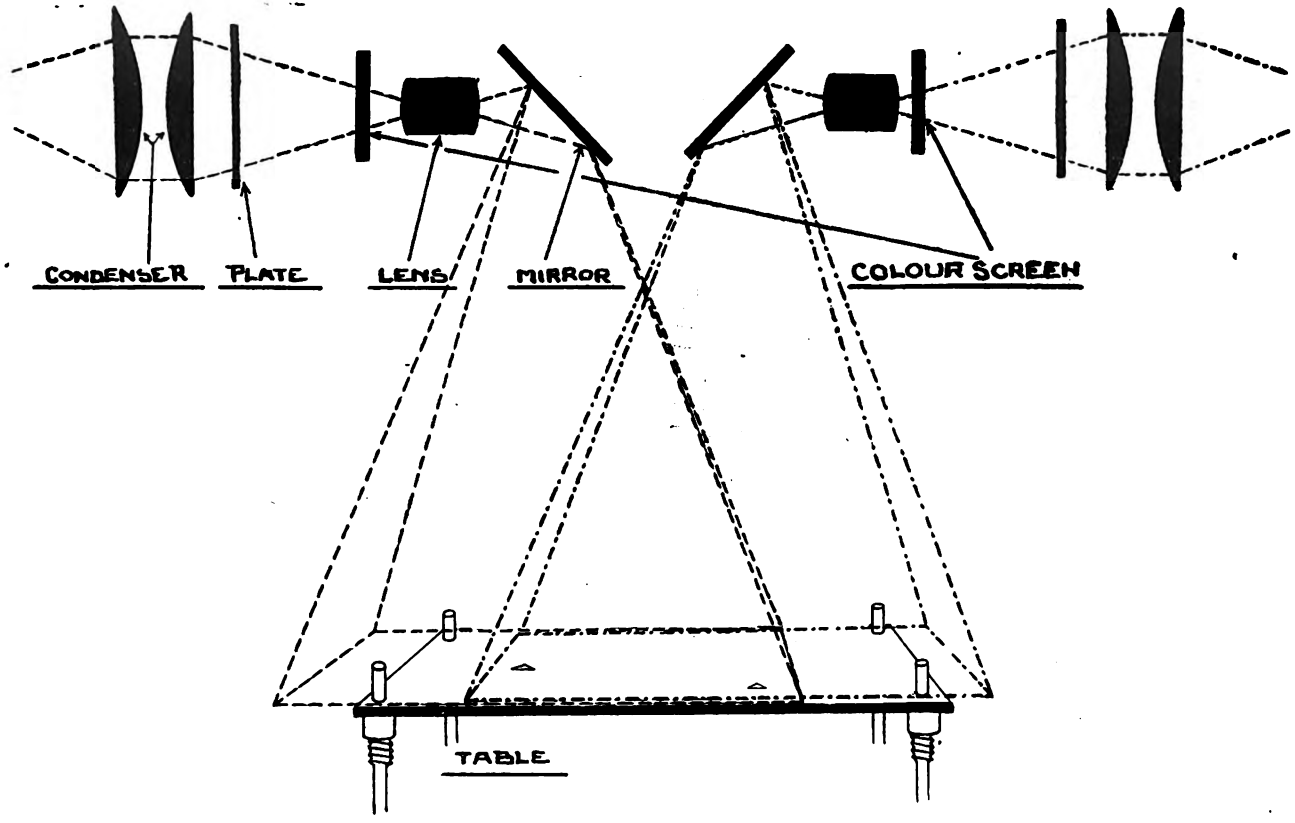


PLATE I.

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explain it, but I think there may be something favourable in an air photograph which is the more marked as the angle of exposure approaches the vertical. Here one deals with a surface whose variations in height are small in proportion to the height of the aeroplane, and objects stand up from it so comparatively little as to limit the depth (and hence alteration in scale) of the image. Whatever the reason may be, the fact remains, and we need apprehend no lack of accuracy due to a small parallactic angle.

We have had our national pioneers in the construction of stereoscopic plotting machines. Lieut. F. V. Thompson, of the Corps, was, I think, the first to evolve a semi-automatic plotter, and Capt. Deville, Surveyor-General of Dominion Lands of Canada, invented an interesting reflector type of stereoscopic plotter. But the subject has not offered much prospect to English surveyors in the past, because we have been faced either with the large-scale survey at home of a relatively flat country, unsuitable to photography from ground stations, or, abroad, with the small-scale mapping for which photography, in general, is unsuited. With the advent of photography from the air we can secure photographs at any angle, and can therefore suit our procedure to the landscape.

There are no British models of stereoscopic plotters on the market, but there are three such which are of great interest, one of which is Italian, and two of which are German.

The Italian model, the " Nistri photo-cartograph," is known to us only by advertisement. It rests upon the old " *camera plastica* " principle, due to Scheimpflug, of a simultaneous projection on to a flat surface from two diapositives which reproduce the relative camera positions in the field. The German models, the Autocartograph and the Stereoplanigraph, are partly optical, partly mechanical. These latter instruments I was able to see, thanks to the kindness of Gustav Heyde & Co., of Dresden, who make the Autocartograph, and of Zeiss & Co., of Jena, who make the Stereoplanigraph.

## The Camera Plastica.

The expression " camera plastica " is the most suitable which the Air Survey Committee can think of. If anyone can suggest a shorter and more applicable alternative it will be received with gratitude. The underlying idea is to place the two views (in the form of diapositives) in carriers, in the positions in which they were taken relatively to each other, and to project the images upon a surface which can be moved nearer to or further from them (see *Plate* I). Each view is, in practice, focussed separately upon images of control points plotted on a white surface, and when the views are combined sharp focus is secured only for such points as lie at a height corresponding to the distance between views and plotting surface.

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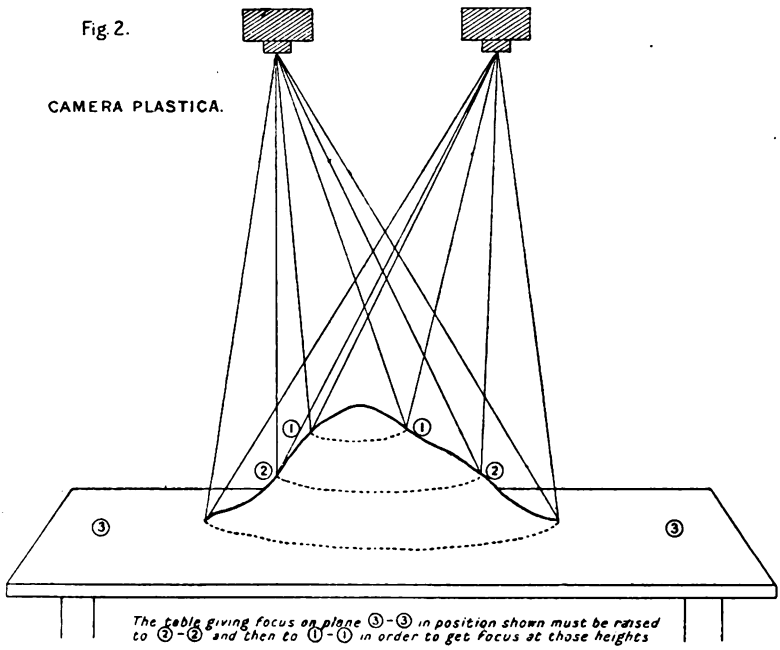
(See *Fig.* 2.) To this simple form all sorts of modifications may be added. In one form, which was seen by members of the Air Survey Committee last summer in Germany, two complementary colours were used. When focus was sharp the image was white, when not in focus a mottled smudge of green and red. In front of the sources of light a revolving wheel cuts off each light in turn at such a speed as to leave the two images simultaneously on the retina. The image rocks backwards and forwards, except where it is in focus, and leaves one with a distinctly after-dinner feeling.

Fig. 2.

CAMERA PLASTICA.


①
①
②
②
③
③
The table giving focus on plane ③-③ in position shown must be raised to ②-② and then to ①-① in order to get focus at those heights

This type of stereoscopic machine is being made under several different names. The name " Inagverfahren " (the " Inag " being simply the initials of a firm) is perhaps most commonly associated with it.

Obviously it is not a difficult matter to convert the movements of the plotting surface in altitude into a fairly good measure of height, by one of two alternatives, namely, (*a*) the combination of complementary colours, and (*b*) the selection of stationary (or focussed) from moving (or unfocussed). Some pantograph arrangement can then be made to copy, at the required scale, the contours so defined; but there are serious difficulties in the way of attaining precision in either contouring or tracing the outline.

In the first instance, it seems probable that it will be difficult to survey ground on which little detail appears. This difficulty is

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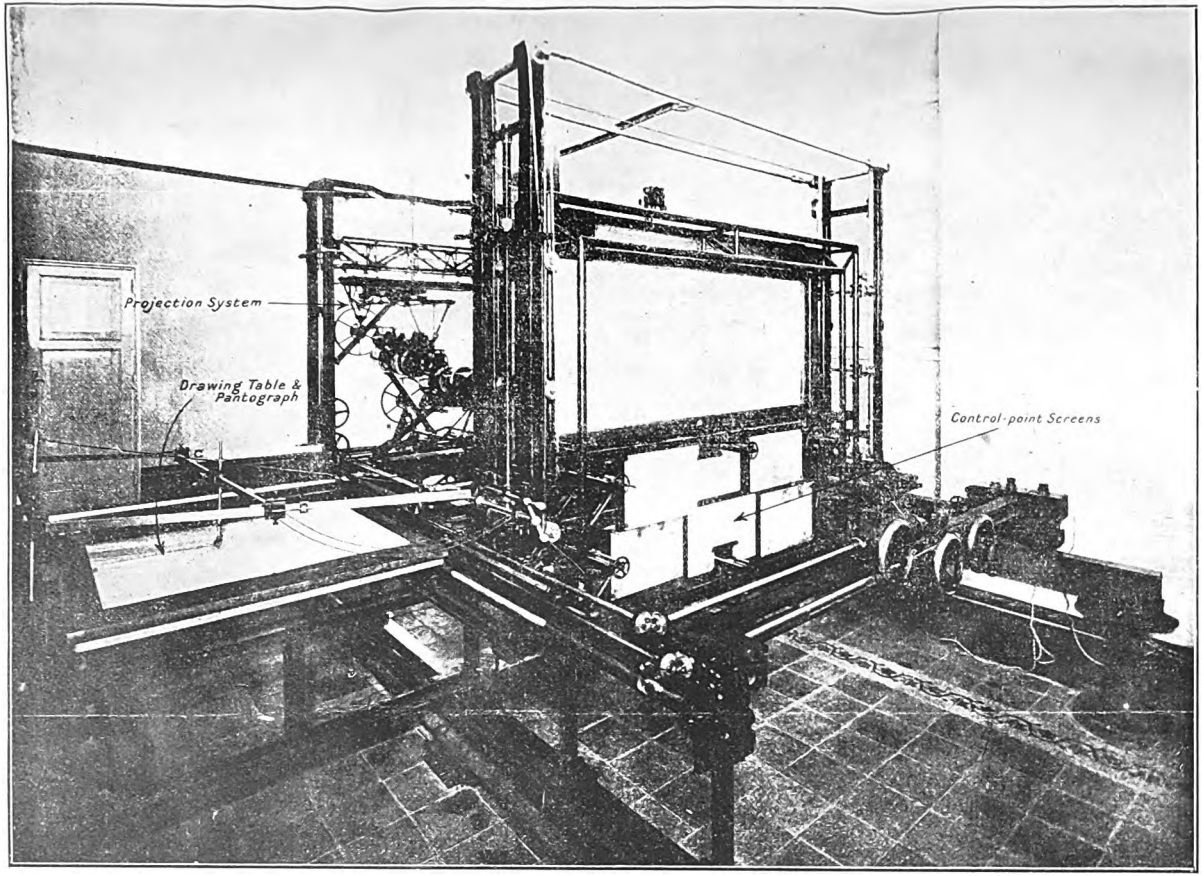


THE NISTRI PHOTOCARTOGRAPH.

PLATE II.

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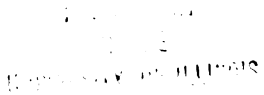

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# NISTRI PHOTOCARTOGRAPH.

Fig. 3.

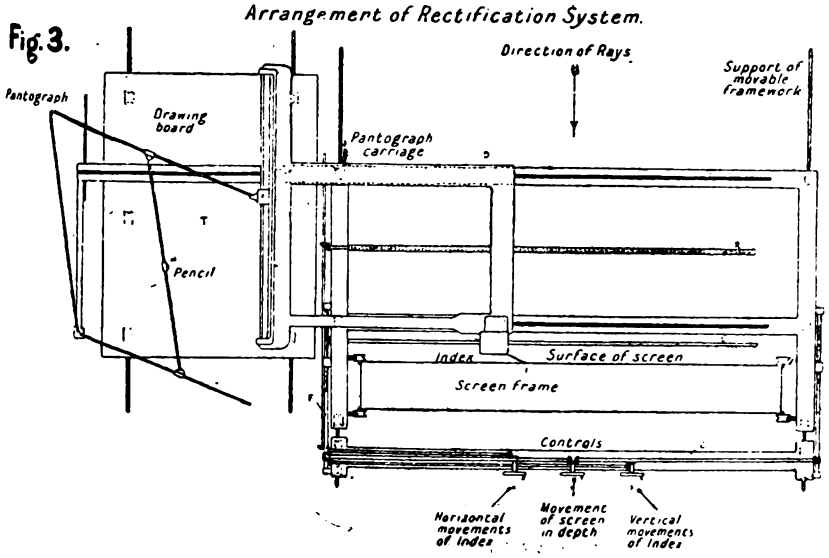
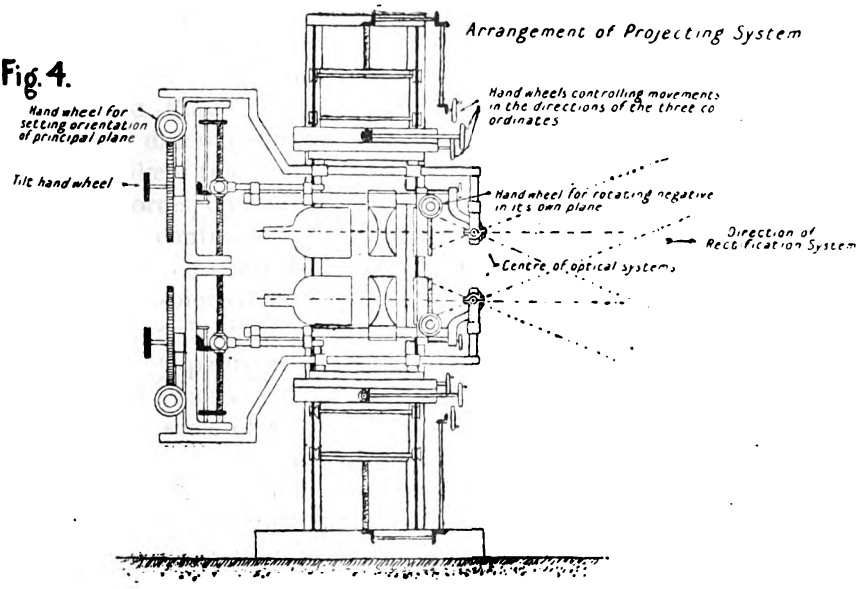



Fig. 4.


Arrangement of Projecting System
Hand wheel for setting orientation of principal plane
Hand wheels controlling movements in the directions of the three co ordinates
Tilt hand wheel
Hand wheel for rotating negative in its own plane
Direction of Rectification System
Centre of optical system

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avoided in the autocartograph and stereoplanigraph by a suitable survey mark.* To examine focus without its aid on bare ground will be difficult. Secondly, it would appear to call for peculiar precision in the relative heights of projectors and plotting surface; and thirdly, there are optical troubles in securing focus at the different heights, without a change in the position of lens and diapositive. Moreover, the scale of the projection will be difficult to reduce to practical limits. It is for the medium scales (1/40000 to 1/5000) that the chief value of photography offers. It is doubtful whether one can secure a projection on these scales. Naturally the results obtained at, say, 1/1000, can be reduced, but the additional time taken in working at a large scale and reducing are drawbacks. There is, however, the other side to the picture. The apparatus is very easy to construct and the results obtained, if possibly, though not necessarily, not of a very high order, will be comparable generally to most topographic contouring.

## The Nistri Photocartograph.

*Plate* II and *Plate* III (*Figs.* 3 and 4) show the general appearance, and some details of the construction of the "Nistri" photocartograph, which, according to a recently-received publication, is now on the market. It embodies the *camera plastica* principle. Judging from the photographs, this machine must stand from 7 to 10 feet high, and occupies perhaps 80 sq. ft. of floor space. The positions and design of the projectors are immaterial for an understanding of the broad lines of the machine. It is sufficient to note that they are movable and that the images are thrown upon a series of screens which are at different distances from the projectors.

It seems likely that the control points (say, 4) are plotted each on the screen corresponding to its altitude. Each projection is, then, fitted to this control by moving the corresponding projector until the images of the control points lie properly and in sharp focus on their correctly-plotted positions. An opaque drawing-board is now substituted for the individual screens, and the contours are traced (and copied by pantograph on the fair drawing) by following the lines of correct focus. It is noteworthy that contours so drawn are correct in the scale of your chosen plane of reference The outline must be plotted in the same way—that is, only such portions can be traced on the board, at one time, as lie at the corresponding altitude. The Nistri people claim that their "photocartograph" is a general-utility instrument; that is, that it may be used for photographs taken with the optical axis at any angle to the ground. This statement should be accepted with some reserve. As a system it lends

* It seems possible that in some manner or other the survey mark is introduced in the Nistri pattern discussed later.

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itself most readily to photographs taken with a vertical axis, because in this case the movements from the plane of reference are a minimum. It would be a matter of obvious difficulty to arrange for screens at distances ranging from the immediate foreground to the far distance.

There is no particular danger of not being able to contour well from vertical-axis photographs. The ratio of horizontal to vertical scale can be varied at will by altering the length of air base (or overlap of the photograph). Little can be said of this model at the present moment, however, because little is known.

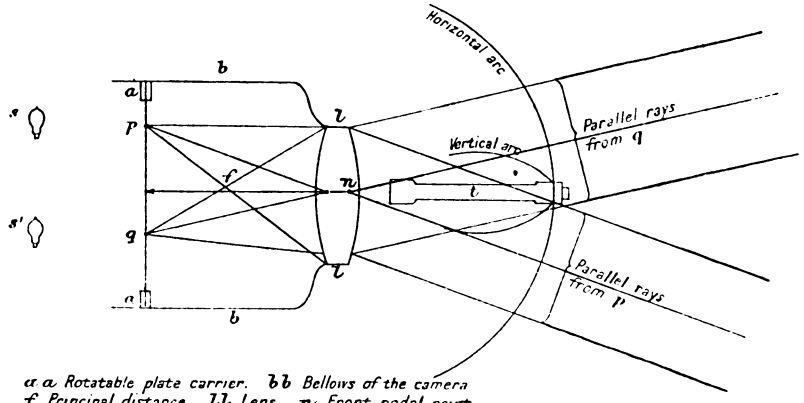
## THE GERMAN MODELS.

It has been possible to study the German machines in more detail. The autocartograph and the stereoplanigraph are essentially different in principle. The former is an intersection method and does not reproduce, directly, the conditions in the field. The latter is an interpolation method and does, much more nearly, reproduce field conditions, but both differ from the projector type in this, that attention is focussed upon the cutting-point of two rays and does not treat the area as a whole. There are one or two matters which are common to both models and may be dealt with separately.

*The Photogoniometer.*—The first models of stereo-comparators-plotters or -autographs, designed to deal with stereoscopic pairs taken in the vertical plane, and either parallel, or nearly so, effected the convergence of rays, proper to the stereoscopic fusion of corresponding images, by shifting one plate with reference to, but still in the same plane as, the other. Where the planes of the plates may assume almost any angular relationship to each other this principle no longer serves. The photogoniometer (see *Fig.* 5),

Fig. 5

THE PHOTOGONIOMETER




*a a* Rotatable plate carrier. *b b* Bellows of the camera
*f* Principal distance. *l l* Lens. *n* Front nodal point
*t* Theodolite. *s s'* Moveable source of light
*p q* Images on diapositive

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which solves the problem in a convenient way, was first designed by Porro, of Milan, and was improved upon by Koppe. The general idea is to place a diapositive in the plate-carrier of a camera at the principal distance characteristic of the camera used in the air for the original exposure. Through the camera lens the diapositive is examined with a theodolite. The camera portion is pivoted round the front nodal point and the vertical and horizontal axes of the theodolite generally pass through that point, too. That, however, is not a vital matter, as the rays from images emerge parallel. The important feature of the instrument is that the lens employed should be as nearly as possible an exact copy of that employed for exposure in the field, and the principal distance must also be exactly the same. The plates employed for photographic surveying show fiducial marks, one on each side, so that lines may be drawn joining opposite marks to intersect in the principal point. They also show corner marks so that the angular distance from centre to corner, on each side, may be tested by measurement on the horizontal and vertical axes of the theodolite.

Supposing that for some cause, even so apparently negligible as particles of dust, the plate is not correctly set with relation to the lens, appreciable errors may be introduced. In the autocartograph (to be described later) a three-point adjustment is used to bring the plate to its true position.

If the exposure in space was tilted, then either the camera, or the theodolite (arcs and all), is tilted accordingly, and, as field conditions can, by this means, be absolutely reproduced, horizontal and vertical angles can be read off directly upon the theodolite arcs.

Even in this simple form the photogoniometer promises to be a most useful instrument. Providing a good reliable method is found of measuring the tilt, either in the air, or afterwards, in a special instrument such as the tilt finder, the photogoniometer promises a speedier and more satisfactory approach to precise survey of detail and to contouring than do methods of rectification. But beyond this direct form of utility, it opens the way to examining stereoscopic pairs of plates in automatic plotters, and is used, although in different forms, in practically all models and designs.

In the autocartograph vertical angles are read on the plate by swinging the objectives of a binocular telescope (which replaces the goniometer theodolite), round a horizontal axis, whilst horizontal angles are measured by swinging the camera (set to the angle of tilt) round a vertical axis. In the stereoplanigraph the telescope is replaced by an auxiliary lens combination, which is pivoted for movement in all directions, whilst the camera is given movements to correct tilt and swing.

*The Survey Marks.*—In looking through the telescope of a theodolite the collimation axis is defined by a graticule of cross hairs. One

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wants some similar "foresight" to direct each eye along this axis when working stereoscopically, and, to serve this purpose, a "mark," a "floating mark" or a "survey mark" (for all three expressions are used) is put in each eye-piece so that it appears, individually, at infinity, or in stereoscopic fusion at that position whose *xy* and *z* co-ordinates are recorded by the instrument. The usual mark (as used by Lieut. F. V. Thompson, for example) was a ball surmounting a pointer. It did not appear (to me, at any rate) to have substance, when "fused"—although the images came together. An excellent type of mark is shown in *Plate* IV, *Fig.* 6, which, when examined in a stereoscope, will be found to take the form of a hollow cone. This type of mark was used with the stereoplanigraph.

The usual type of survey mark.

## THE AUTOCARTOGRAPH.

The general appearance of this instrument is shown in *Plate* V, and the working of it in *Plate* VI. In this latter Plate (which refers to an earlier model than *Plate* V) the photogoniometer is shown under its German name of "Bildmess theodolite."

*Geometry.*—The two azimuthal arms are the projections, on the horizontal plane, of the rays from the two ends of the air base to the object. It would be difficult to design the machine in practice so as to include an actual point of intersection of these arms, and this difficulty is overcome by the use of similar triangles.

The left-hand arm is that which defines the bearing or azimuth; for it is moved to right or left, sliding, in its sleeve, along the distance piece. This movement brings the survey mark in the left eye-piece on to the object. The distance piece is now moved to, or from, the line of clamps (but remaining parallel to it), sliding up or down the left-hand arm and rotating, as it does so, the right-hand arm until the survey mark in the right-hand eye-piece falls also upon the object. *Fig.* 10 shows clearly the triangle which is actually formed, with its base on the distance piece and, as its sides, the right-hand arm, and a line parallel to the left-hand arm. Now these arm movements have to be given by the observer who is looking through the binocular telescope at the plates in the plate-holders of the goniometers. In *Fig.* 8, *Plate* VI, it will be seen that these goniometers rotate around a vertical axis. They are first of all "set" on control points, separately, in their correct positions relatively to each other, as will be described later. Subsequently, by moving them round their vertical axes, the same effect is obtained as by rotating the telescope of the goniometer (described above) round its vertical axis. The extent of rotation, governed by a system of gear wheels, moves the arms relatively to each other. Heights are obtained by reading the position of two further arms or levers, which are moved by elevating

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# PLATE IV.

FIG. 6.—A good type of Survey Mark. Similar to that used in the stereoplanigraph. Examine through a stereoscope.

FIG. 7.—A stereogram such as is produced (as an accessory to the map) on the autocartograph. Examine through a stereoscope.

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# SIMPLIFIED DIAGRAM OF THE AUTOCARTOGRAPH.

Fig.8.

Plan

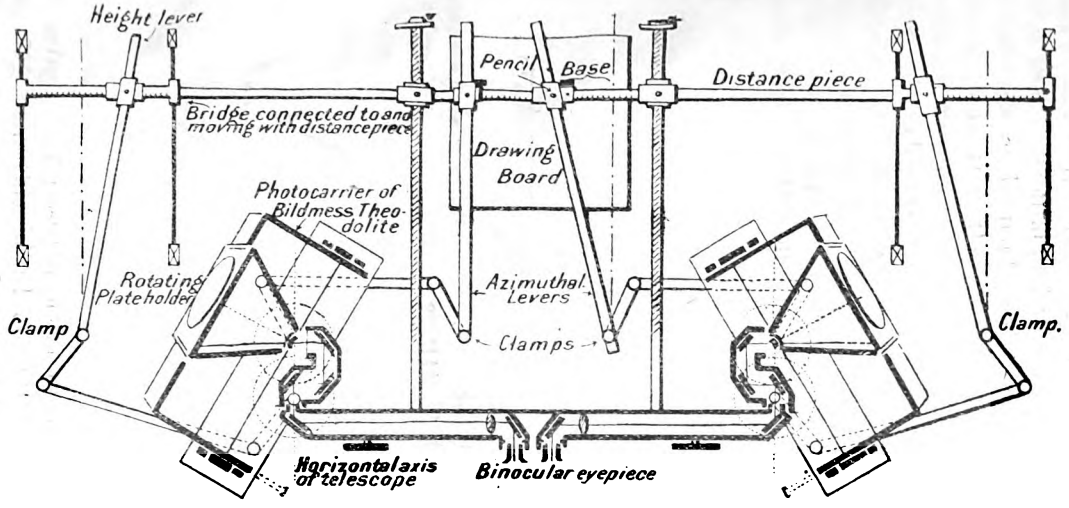


Fig9.

Elevation

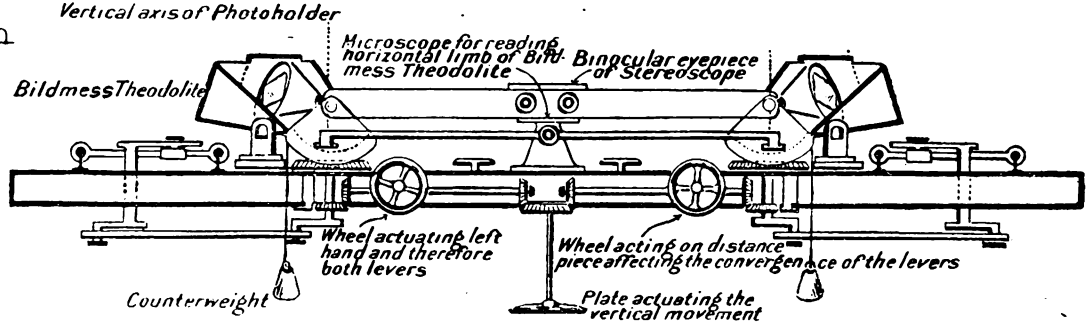
Vertical axis of Photoholder
Microscope for reading horizontal limb of Bild. mess Theodolite
Binocular eyepiece of Stereoscope
Bildmess Theodolite
Wheel actuating left hand and therefore both levers
Wheel acting on distance piece affecting the convergence of the levers
Counterweight
Plate actuating the vertical movement

PLATE VI.

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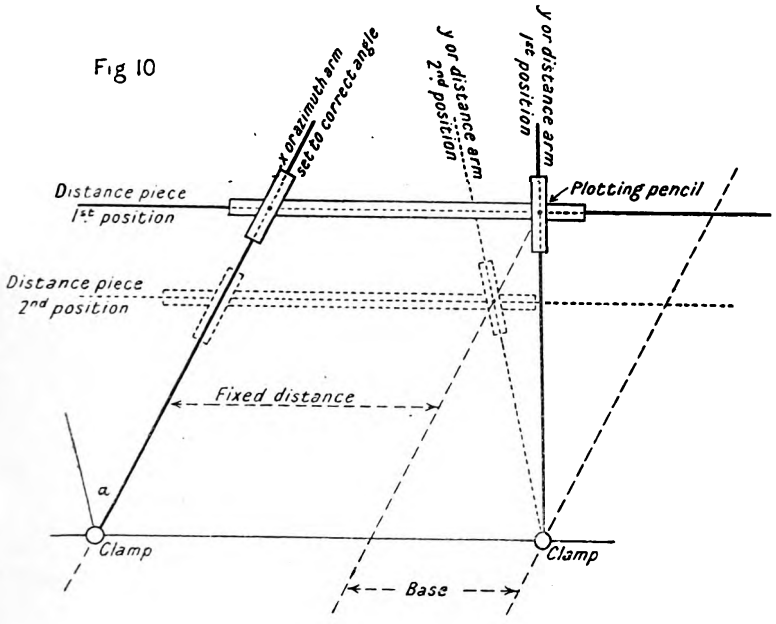
or depressing the objectives of the telescope round horizontal axes, which are shown in *Fig.* 9, *Plate* VI. The heights themselves are defined by the usual equation $h=d \tan \theta$ (where $d$ is the horizontal distance and $\theta$ the angle of elevation or depression). It will be noticed that horizontal and vertical angles would, in the goniometer described above, be read on the horizontal and vertical arcs of the telescope, and that the autocartograph adaptation is to give the horizontal movement of the telescope to the plate-holder whilst keeping the telescope itself on a fixed azimuth, and to rotate the telescope vertically whilst holding the plate-holder at a constant angle to the vertical. The pivotal lines of plateholder and telescope intersect in the lens of the goniometer. The survey marks are in the eye-pieces of the binocular telescope.




*Plotting.*—The position of the drawing-board is shown in *Fig.* 8, *Plate* VI. On this board are plotted the control points, X co-ordinates being measured parallel to the distance-piece and corresponding, therefore, to the movements of the left-hand arm and of the left-hand driving-wheel. Y co-ordinates, perpendicular to the base, are governed by the right-hand wheel and by the movements, to and from the machine, of the distance-piece. Heights (or Z co-ordinates) are perpendicular to the plane of the board, and correspond to the rotation of the telescope objectives, and to the drive from a potter's wheel (worked by the foot) called "Plate actuating the vertical movement" in *Fig.* 9, *Plate* VI. The pencil is held in the

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sleeve which keeps the right-hand arm to its position on the distance-piece. It can be dropped on to the paper by an electric switch in front of the observer. The pencil can be left in contact with the paper to draw automatically (in cases where plotting affects only X and Y movements on a horizontal plane, *e.g.*, tracing a contour with the height lever clamped) or can be used for point-by-point plotting, where the movements include Z or height measurement and are too complicated for following automatically. As explained above, the survey marks define the two optical axes, and position is not correctly determined until the mark is in actual stereoscopic fusion with the point of detail in question.

*Setting the Instrument.*—The preliminary adjustments to the diapositives in the plate-holders of the photogoniometer have been dealt with before. When they have been concluded, the plates (or diapositives) are adjusted in turn upon the control points. Normally, exposure is made, in the aeroplane, either with a vertical axis or at some pre-arranged angle of tilt. (The autocartograph is primarily designed for tilts of about 60 degrees.) Whatever the actual angle of tilt may have been, an estimated value is taken and the plate-carrier is tilted to correspond. The following routine is then completed :—

(*a*) The horizontal angles between the images of three or more control points are measured by rotating the photogoniometer and reading the included angles, as observed through one arm of the binocular telescope.

(*b*) Using these angles, a graphic resection is made from the plotted control points and gives preliminary and approximate (say, within 100 metres) figures for the X and Y co-ordinates of the position of exposure.

(*c*) Vertical angles are then read on the diapositive by rotating the objectives of the telescope and, using the approximate horizontal distances obtained from (*b*), the approximate height of the point of exposure is calculated ($h=d \tan \theta$).

(*d*) Using the approximate data so obtained for each exposure, and so for the air base, the plates (in combination) are fitted, by trial and error, on the plotted trigonometrical control.

The programme outlined above may take from two to four hours to complete. A fairly good position (say, to within 6 to 10 minutes of the true tilt) is easily procurable. The final adjustment is an affair of practice, and of honest and careful manipulation. Obviously, if Major MacLeod's tilt finder answers to expectations it will save considerable time at this stage. It is to be noted that the mathematical solution of the position in space, thought indispensable in earlier models, has been entirely given up. Indeed, it meant days,

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rather than hours, of work, and was an insuperable bar to the economic use of the instrument.

*Extra Fittings.*—

(*a*) A motor drive can be used to work the arms, and to combine motions of the X and Y co-ordinates. This device may be useful in tracing contours, for such combined movement is easily controllable by a wheel, which resembles a motor-car driving-wheel, and can be regulated to any desired speed. It is, however, of little value if the potter's wheel is to be used at the same time. It was certainly beyond me to follow the changing height with the potter's wheel, while moving the azimuthal arms, fast, with the motor. I doubt the real usefulness of this modification.

(*b*) *The Front Drum.*—The plotter works away in front of a maze of wheels and movements, and could not readily see what he had done, when working with the first models. A drum has, therefore, been added where the plotter can see it, and on this drum is drawn a replica, at any required enlargement or reduction, of the plan on the drawing-board. The drum revolves and, in doing so, naturally suffers an alteration in diameter (and hence in scale), for the roll of paper on it must start somewhere. The effect of this uneven diameter is probably not entirely negligible, but the fitting is a good one if only on the score of the convenience of the plotter.

(*c*) *Profiles and Stereograms.*—Profiles can be drawn by a device fitted in front, and also small but interesting stereograms. A sample of these stereograms is given in *Fig.* 7 of *Plate* IV. It should be viewed through any convenient stereoscope.

(*d*) *Co-ordinate Indicators.*—These indicators show the actual values of the X, Y and Z co-ordinates at any moment corresponding to the movements which have been given to the machine. It is undoubtedly a convenience to have this possibility.

*Cost, Space, Weight, Time and Staff.*—The autocartograph costs something about £4,500. It is not possible to be more precise, because this class of instrument seems to fluctuate a good deal in price. It stands about 5–6 ft. high and covers about 100 sq. ft. of floor space.

Its weight I should put at about 2–3 tons. The staff normally employed is 1 part- and 2 whole-time mechanics and draughtsmen. The adjustment of a pair of plates takes, say, 3 hours, on the average, and the plotting of a pair of plates about another 6–8 hours. These figures are but approximate, since the type of country and the class of photograph introduce variable factors.

*Test Survey.*—About a year ago Professor Hugershoff, the designer

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of the autocartograph, offered to send over his own cameras at the firm's expense, and to produce a map from the exposures made in the air with these cameras. The offer was accepted, and the photographs were taken. Before the map could be made it was necessary to send data concerning control points (*i.e.*, their co-ordinates and heights). It is not easy to procure such data in England without original survey on the ground, because the trigonometrical stations of the Ordnance Survey are generally buried (and cannot, therefore, be identified on a photograph), whilst the spirit-levelling does not, generally, extend to them. Positions were therefore measured from the 1/2500 plans, and heights were obtained by interpolation between contours. The map produced by Professor Hugershoff answered very well to the data he was given. In one or two instances the contouring left the surface of the ground where woods and copses hid the view. The autocartograph, in fact, came well out of the test, but the cameras supplied did not. The focal length was insufficient to cover the plate, and definition in the background was very poor. The map could be extended over the foreground only. But it is the plotting machine, and not the camera, which is under discussion, and there seems no doubt that it is capable of fast and good automatic plotting.

## THE STEREOPLANIGRAPH.

The stereoplanigraph is a more difficult instrument to grasp than the autocartograph. This is partly due to the employment in its construction of a number of daring optical expedients, or combinations, and partly, in my opinion, to a real lack of that simplicity which is so desirable.

The essential difference between this resection type and the autocartograph is that the positions of exposure in space change places with the position of intersection. The plotter, or observer, is "at the point." The photogoniometers are the positions in space and they are movable, therefore, away from, and in relative height to, the observer.

*Plate* VII, *Figs.* 11 and 12, give general views. Several features in them are easily identifiable. The plotting table, on the right in *Fig.* 11 and on the left in *Fig.* 12, is clear, and so also are the two photogoniometers which appear on the top rear of *Fig.* 11 and on the right of *Fig.* 12.

The driving-wheels for X and Y motions are seen on the left and right of the front of the instrument, in *Fig.* 11, and the "potter's wheel" (Z co-ordinate) appears below the observer's position. The eye-pieces of the binocular telescope are identifiable, on *Fig.* 11, vertically above the potter's wheel.

Before going further, it will be as well to show generally the

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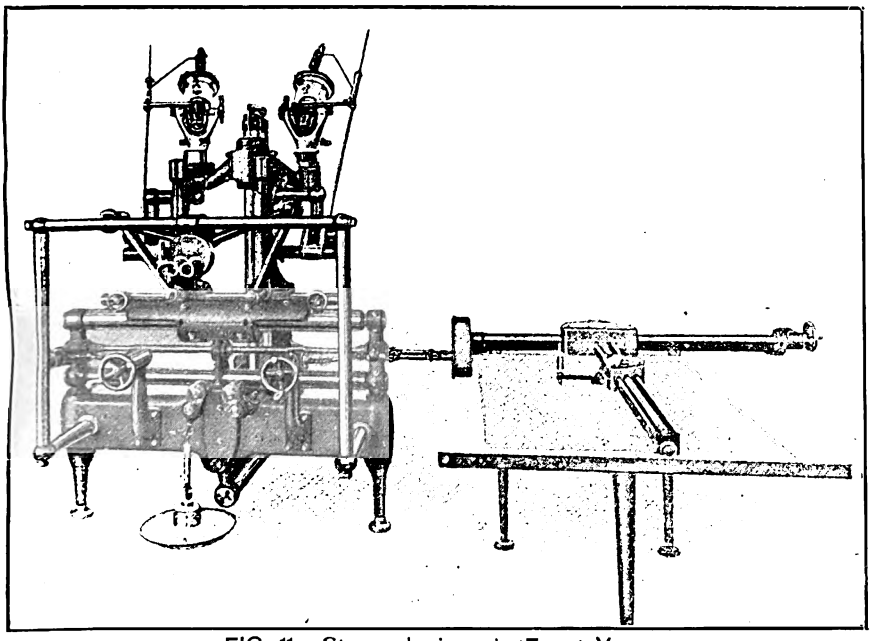

FIG. 11.—Stereoplanigraph (Front View).

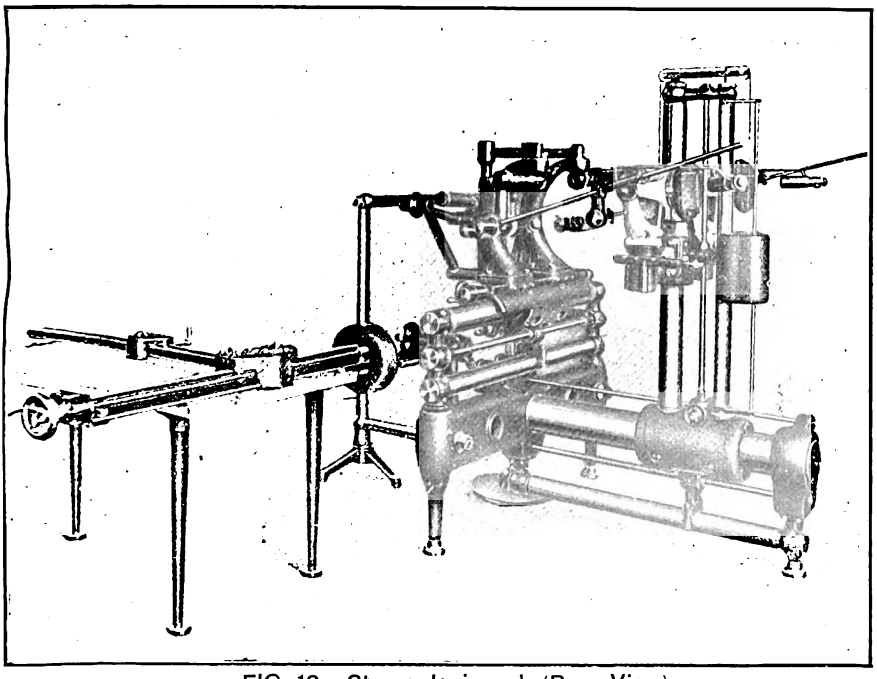

FIG. 12.—Stereoplanigraph (Rear View).

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mechanical movements which measure the X, Y and Z co-ordinates. Looking at *Figs.* 12 and 14, it will be seen that the photogoniometers are mounted upon a carrier which slides up or down between two steel guides. This up-and-down movement is the Z or height movement (effected by the potter's wheel). The carrier and its vertical guides stand upon a metal drum which slides backwards and forwards along a stout steel cylinder, and brings the photogoniometers nearer to, or further from, the observer. This is the Y movement (effected by right-hand drive). The X movement is a simultaneous motion of the two survey marks. Now, these marks are in

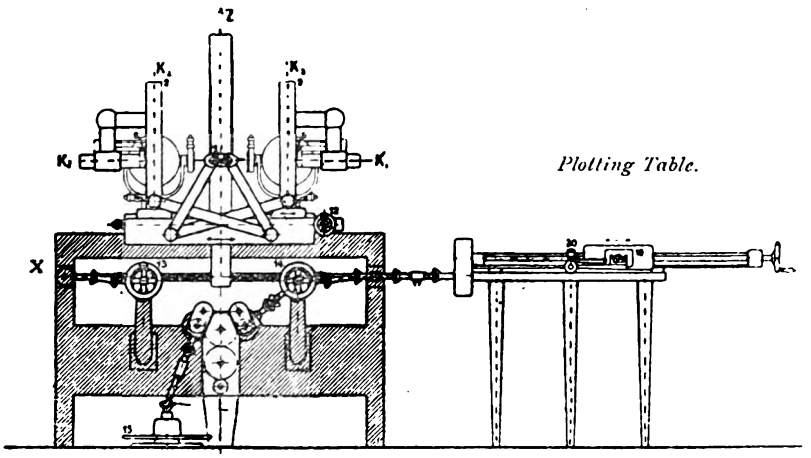


FIG. 13.

*Key to Fig.* 13.. *Front view.*

$K_1$ $K_2$ Carden Axes.
2. Survey Mark Carrier.
6. Adjustment of Dove prisms.
12. Adjustment of shifting $PP_1$.
13. X-drive.
14. Y-drive.
15. Potter's wheel (Z-drive).
19. Sliding arm.
20. Drawing pencil.

objectives, which are on the rear face of the main instrument, and can be seen at the instrument end of the two guides (whose object will be explained later) which lead from the photogoniometers (see *Fig.* 12 and *Fig.* 14). The distance between the two objectives (with their survey marks) should—if we were going to construct the actual triangle—be zero. As that is not, instrumentally, possible, the distance between them is made equivalent to that length on the autocartograph distance-piece, which is kept constant, between the right- and left-hand arms (see *Fig.* 10).

*Fig.* 14 gives a bird's-eye view of the instrument. It will be seen from this figure that there is no direct connection between the survey

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marks (P and Q of *Fig.* 14) and the photogoniometers, to connect the apparent movements of the survey mark with the corresponding Y and Z movements.

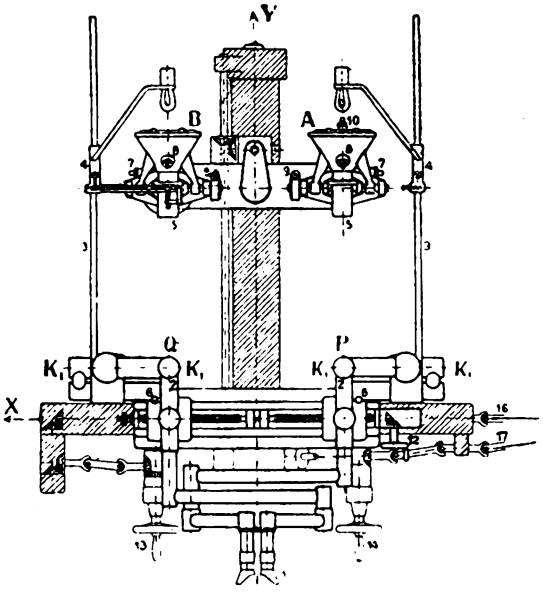


FIG. 14.

*Key to Fig.* 14.

A and B. Plate holders.
P and Q. Survey marks.
$K_1$ $K_2$ Carden axes.
1. Eye-pieces.
2. Survey mark carrier.
3. Auxiliary combination guide and cam.
4. Guide-block of combination guide.
5. Auxiliary combination.
6. Adjustment of Dove prism.
7. Adjustment of parallax.
8. Adjustment of swing.
9. Adjustment of tilt.
12. Adjustment of distance between survey marks.
13. X-drive.
14. Y-drive.
16. Transmission of X.
17. Transmission of Y.

Consider P and Q as one point R (see *Fig* 15).

When the machine is set at R, correct for the stereoscopic fusion of images *a'* and *a"*, the parallactic angle at R is along a definite bearing measure of the distance of that point from the air base. Suppose we now look at images *b'* and *b"*, we have then to move the goniometer-carrier further away (although, for simplicity, in *Fig.* 15 we have moved R by a corresponding distance back to R'), and what enables us to see *b' b"* (instead of *a' a"*) are auxiliary lens combinations which hinge at points *h'* and *h"*. One can imagine the optical axes or

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lines of collimation between R and $h'$ $h''$ (R′ and $h'$ $h''$) as being elastic yet taut strings. The auxiliary combination is composed of a bi-convex and a bi-concave part. It hinges in front of the goniometer lens, at the rear focus of the combination, and brings the rays to a point again on the survey mark. But as the photogoniometer moves

Fig. 15

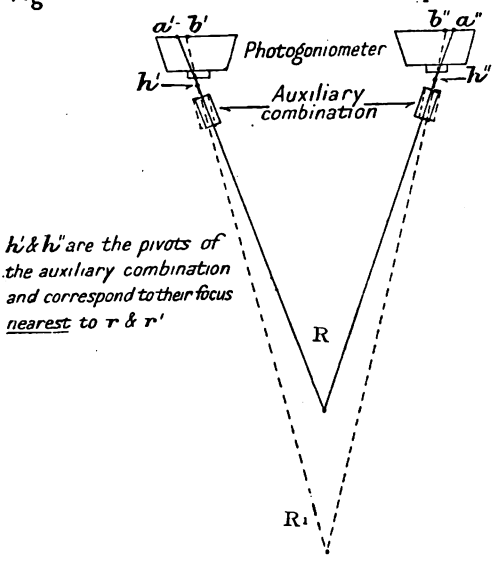
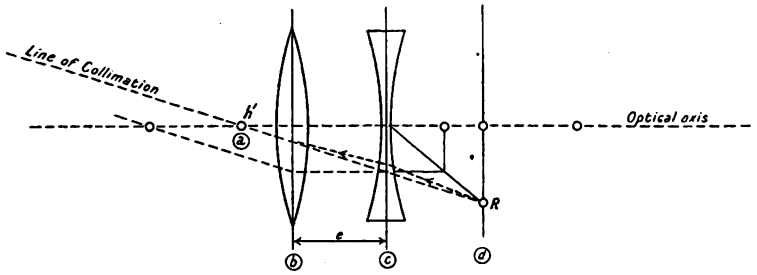



Fig. 16. AUXILIARY LENS COMBINATION.




As y co-ordinate increases ⓐ (the pivot) moves to left with the Photogoniometer, ⓓ moves by the same amount, ⓒ not so much and by separating from ⓐ increases distance ⓒ ⓓ — maintaining focus on R (the survey mark) which remains fixed

backwards and forwards (see *Fig.* 16) the image must be brought to a point at varying distances from $h'$, and this is effected by a movement of the bi-concave lens relative to the bi-convex.

The movement of the lenses in the combination is regulated by a cam on a guide shown in *Fig.* 14.

One advantage secured by this arrangement is that the magnification of the image at R′ is greater than it is at R, and by an amount

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equivalent to the greater distance of the point from the air base. Now this is a real advantage over the autocartograph. Accuracy of plotting depends primarily on the size of the parallactic angle, but it is also influenced by the size and clearness of the image. In the autocartograph the background diminishes in scale. In the stereoplanigraph the same scale obtains throughout.

Before leaving the auxiliary system it will be well to add that it moves, or pivots, on $h'$ and $h''$, vertically as well as horizontally, and so completes the optical connection in both Y and Z. It is unnecessary, probably, to add that the auxiliary attachment and the carden-links carrying the survey marks correspond to the telescope of the theodolite portion of the goniometer previously explained.

Now to hark back to the survey marks, we come to an amazing optical system. Four serious troubles arise in the design of the binocular telescopic system :—

(*a*) The inclination of the line of collimation, from goniometer to survey mark, varies with the position of the goniometer. The lines of collimation ($h'$ R, $h''$ R, etc.) are thus not normal to the plates unless an equivalent rotation is given to the objectives which carry the marks.

(*b*) If such a rotation is given, it will also rotate the landscape, viewed in each eye-piece, round the optical axis—and in order to maintain a proper stereoscopic fusion some counteracting optical measure is necessary.

(*c*) The observer must, for convenience, remain sitting in the same position, but the X movement would carry eye-pieces with it, were connection between survey marks and eye-pieces rigid.

(*d*) The images have to be reversed in order to allow them to be seen in their proper relative positions.

The first point is met by the insertion of optical carden-links and by the rotation of the objectives carrying the survey marks.

These carden-links have the additional effect of rotating the landscape round the particular image which is being plotted. The effect of this rotation (the second of the difficulties alluded to) is to introduce a loss of parallelism between the eye base and the air base. But, to obtain a satisfactory stereoscopic fusion, the proper relationship must be maintained, and, in order to counteract the rotation, Dove prisms are introduced in the paths of each ray.

Difficulty (*c*) might have been solved by carrying observer, chair and all, on the X movement. Admittedly this would be drastic and, consequently, to meet both *c* and *d*, no less than 16 optical (and mostly working) joints are interposed between each eye and its survey mark, in order to procure the necessary elasticity and inversion.

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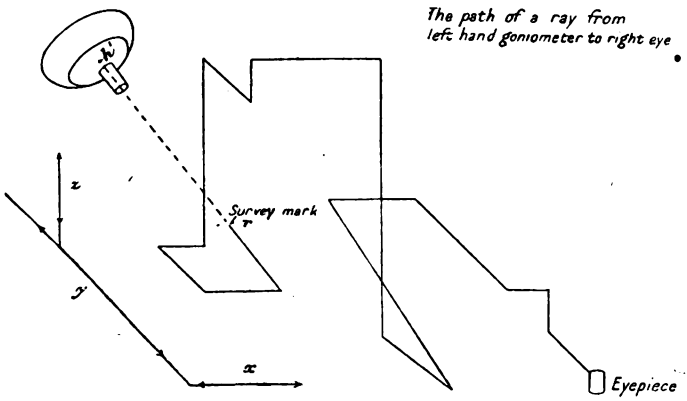
The dotted line (*h'* R of *Fig.* 17) is, however, kept in its correct position by the guide which directs the auxiliary combination upon the survey mark (and turns the latter to face the required direction), and it would seem that, if this optical line is kept to its proper azimuth, *i.e.*, if the image of the point in question is brought to a focus on the survey mark, any subsequent irregularities between the survey mark and the eye are relatively immaterial. Loss of light can, however, hardly be avoided.

The preliminary adjustments are such as to reconstruct the exact relative positions of the cameras in the air. There are, therefore, adjustments for tilt, swing and direction of optical axis on each goniometer.

Fig. 17




The geometry of the solution of the position in space is simple enough, and needs no detailed explanation, but it implies that each goniometer is relatively at its correct height. On one, therefore (left-hand, looking from the observer's seat), there is an adjustment for height relatively to the goniometer carrier (in the Z co-ordinate). It is also necessary to allow of a small adjustment in Y (or range) to compensate for the projection of the ray into the required plane, and on the right-hand goniometer a slide is provided by which this adjustment is made.

The survey marks are movable relatively to each other on the X (or azimuth) movement in order to set to, and clamp at, the distance proper to the occasion. Once clamped, the survey marks move together, and no longer relatively to each other.

The plotting-board pencil moves over the surface of the board according to the movements of the X, Y and Z drives. It is connected to them by worm gearing with jointed shafts and bevel gears. The scale of the instrument itself, *i.e.*, of the landscape as one measures it, is limited by the length of base available (38 cms.),

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but any scale can be used for plotting which lies between $\frac{1}{25}$ and $\frac{25}{1}$ of the instrument scale. A gear-box connecting the drives to the first (and, perhaps, only) table allows of a range from $\frac{1}{5}$ to $\frac{5}{1}$, but a similar and second table drawing a second map adds the additional factor. It is noteworthy that Y and Z drives can be altered in purpose, in order to allow of plotting over the whole range of possible tilts. The arrangements so far discussed are suitable for plotting between tilts of 40° and 90° (from the vertical). The Y and Z movements can be exchanged for tilts from 0° to 50°.

The preliminary arrangements for adjusting particular views to the control points follow pretty well the same order as those described for the autocartograph. I think, perhaps, they are inclined to be a little more tedious, because of the care required in effecting the adjustments. The instrument is not of so robust a type as the autocartograph, or so it seemed at the time of our visit. The time taken to adjust the two views separately and then to combine them is about four hours, normally, but may be cut down with vertical axis and horizontal axis pairs to about two hours. Plotting is, I think, easier on the stereoplanigraph than on the autocartograph. With the latter we made errors of 6–10 metres in plotting pretty consistently for an hour or two. With the former the average was considerably less.

The size and weight of the stereoplanigraph are very similar to those of the autocartograph. No details are available as to price, but it is certainly of the same order as, and will probably be found identical to, that of the autocartograph.

The same number of staff, two permanent and one half-timer, are required for working.

The stereoplanigraph is a fascinating instrument and Doctor von Grüber, who explained it to us with great patience, is as great an expert as he is courteous as a guide.

## SUMMARY.

There are at least three models of these machines on the market. Of these the Nistri pattern is known to us only from advertisement, in which few details are given. It is not possible to pass judgment upon it.

The autocartograph designed by Professor Hugershoff and manufactured by Gustav Heyde is a large and costly instrument, but does actually perform the task it attempts. The stereoplanigraph manufactured by Zeiss and Co. of Jena is also a practical and efficient instrument. Both models are of general application; that is, they will plot from a stereoscopic pair at whatever angle exposure may be made in space. They are, in this respect, a considerable advance upon the stereo-autograph.

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The photogoniometer, which enters into their design, is a valuable instrument in itself. The plotting machines are too heavy to accompany any but large formations to the field, but a photogoniometer might prove invaluable with lower formations, and particularly so if a good measure of the tilt of exposure can be made.

For any large operation a stereoscopic plotting machine of the autocartograph, or stereoplanigraph, type would be of the greatest value.

Their purchase price will be against their introduction into peace-time surveys, and the more so as they are fitted neither for cadastral nor for small-scale mapping. Nevertheless, the call for good topographical maps of areas which are difficult of access, or which offer only a short field season, is not an uncommon one. If photographic surveying is chosen as the suitable method, then it would seem that the last two instruments I have described would be well worth a trial, for, if the price be forbidding, the subsequent labour in the office is more than correspondingly lightened. In my opinion the greater initial cost would soon be wiped off in competition with any photographic method based on the rectification of individual exposures. This is, of course, only an expression of personal conviction, but it is borne out by history. Photographic surveying (or rather, topography) from ground stations has gone through the same graphic stages as we have recently passed through in mapping from air photographs, and has developed into the stereoscopic stage represented by the stereo-autograph.

It is probable that the precision obtainable from air photographs will never be of the same order as that from more stable, and easily fixed, ground stations, but the autocartograph and stereoplanigraph can plot from such photographs as well as from those taken in the air.

Perhaps, after all, the most serious impediment to the more general use of these German instruments is the limitation to their employment imposed by the makers.

Thus up till recently governments were graciously allowed to purchase so long as no private work was done, and private purchasers had to form national companies which then acquired, on agreement to pay royalties, the sole national rights. Such restrictions are obviously well-nigh intolerable, but will have the welcome effect of setting us all to work to design something for ourselves.

## Authorities.

The *Stereo-autograph* of Von Orel, to which the autograph owes its general design, is described in *Maps and Survey*, 2nd Edition, Cambridge Press, by A. R. Hinks, and in the *Geographical Journal* for April, 1922, by the same author.

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The *Autocartograph* (a previous model) was described by Major M. N. MacLeod in the *Geographical Journal* of April, 1922.

The *Autocartograph* and *Stereoplanigraph* are described in the Report of the Air Survey Committee, No. 1, 1923. H.M.S.O. (*Plate* VI, *Figs.* 8 and 9 are borrowed from this Report.)

German literature is voluminous on this question. The following are quoted as bearing particularly on the design of the machines described above.

"*Leitideen bei Konstruktion der für Raumbildmessung dienenden Auswerte-Instrumente.*" Dr. Otto V. Grüber, Jena. (An extract from an article in *Mitteilungen aus dem Markscheidewesen*, 1922.)

"*Der Stereoplanigraph der Firma Carl Zeiss, Jena,*" von Dr. Otto V. Grüber. An extract from *Zeitschrift für Instrumentenkunde.* (*Figs.* 13, 14 and 16 are borrowed from this atricle.)

"*Grundlagen der Photogrammetric aus Luft Fahrzeugen,*" Hugershoff and Cranz, Stuttgart, Witwer, 1919.

"*Die Phototopographie und ihre Andwendung auf Flugzengaufnahmen,*" von Dr. Ing. R. Hugershoff. (An extract from the *Geographische Anzeiger*).

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A very useful bibliography is given in Appendix VI of the Report of the Air Survey Committee for 1923.

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# *THE TRAINING OF TERRITORIAL R.E. UNITS.*

*By* MAJOR H. G. EADY, M.C. and CAPTAIN G. E. GRIMSDALE, R.E.

THERE appeared, in the September number of the R.E. JOURNAL, an article on the training of a Territorial Army Field Company, in which a very comprehensive, though perhaps rather Utopian, scheme of instruction and organization was outlined. The article did not, however, more than touch upon the most important period of training—the annual camp ; and it is the purpose of the present writers merely to try to add a few notes on this period, to show the main difficulties which arise, and to suggest means by which assistance could be given to the T.A. units by regular units of the Corps.

So far as the training previous to camp is concerned, one feels that the difficulties were, if anything, underestimated in the September article, at any rate for units in the London or industrial areas. One is up against "*unavoidable* cases of absence," which cannot be altered by the "nature of the instruction given, the recreational facilities provided, or the state of the organization of the unit." These absences, causing the continual change in personnel present on consecutive nights of instruction, make progressive training of any kind extremely difficult, with the very limited number of instructors at the disposal of the unit. Everyone will agree with Major Palmer's statement that "the foundation on which the efficiency of the unit can alone be built is an organization in which each of its members carries out personally the duties which belong to the post which he holds" ; and one of these duties is the instruction of men by the unit officers and N.C.O.'s. Herein lies the main difficulty, a difficulty which is greatly emphasized at camp, as the facilities for educating these officers up to the standard of instructors are small. Every officer, during the first four years of his commissioned service, has to complete a six-weeks' course at the S.M.E., a course which may be carried out in instalments at considerable intervals of time. This is the only obligatory training at a school of instruction which he has to undergo, and during this period he is supposed to get the grounding of all the technical work of a field company. Can this be in any way adequate to train him to train others? He is the first to acknowledge that it is extremely inadequate. The only further training that he obtains, except in the camp period, is in the evenings in the drill hall, where the sole instructors are the permanent staff, who have all other ranks to cater for ; in the days spent on musketry ; and in the occasional week-end staff rides. The scheme of correspondence courses, suggested in the previous article, is an admirable one for increasing the

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theoretical knowledge of the officer personnel, but it cannot really deal with the difficulties of teaching the practical instruction of others.

The beginning and end, then, of the difficulty in the pre-camp period, really seems to be—lack of instructional staff.

Before discussing actual camp organization, one must again emphasize the great difficulty with which the P.S. has to contend—that practically no two individuals in the unit have reached the same standard of training. Many sappers have possibly never seen a pontoon, except in a store, and have never handled an explosive ; drivers have never driven horses, except from a cart ; and horses are provided which have never been in service harness. Alongside these are N.C.O.'s with possibly considerable war experience, but whose knowledge of training is small, and rusty. In addition, one often gets officers who have only been commissioned just previous to camp, and who are completely untrained, not only in the technical branches, but also in the elementary drills, etc. To compete with all this, there is still only the same permanent staff. Now, if any real value is to be obtained from such a short period of training, the first essential is a thoroughly organized scheme, which can only be based on an adequate provision of officers, etc., qualified to instruct. It is again this fundamental basis which is lacking in the most important early days of camp. Most T.A. officers of any service, and many N.C.O.'s, are fit to carry out the instruction of their unit after a sharp " brush up," but, as has already been pointed out, they have neither the time nor the facilities for really keeping up-to-date in their practical training. What, then, seems essential during the first days of camp, is an intensive course for officers and N.C.O.'s, so as to fit them to undertake the instruction of their subordinates, while the other ranks can be kept in the all-important hands of the P.S. drill instructor. It is exactly at this period that the Adjutant and his staff are most heavily employed on other duties. Camp details, pay troubles, sanitation, orders, rations, horse-lines, etc., in units which have, to all intents and purposes, just been mobilized, will occupy almost the whole time of the P.S. The Adjutant has to be the father and the mother of the unit to ensure smooth working. It is physically impossible for him to do this and to supervise adequately the training of officers and N.C.O.'s. Lectures, demonstrations, etc., take many hours' careful preparation, especially when so much has to be crowded into so short a period, and when it is so essential to capture and hold the interest of the audience. The administrative work and this instruction cannot be done by one man : the adjutant must obtain assistance, as his P.S., however excellent it may be, is scarcely likely to be capable of instructing officers and N.C.O.'s in all branches of the technical training required.

To overcome this difficulty, it is suggested that regular officers should be attached for the period of camp. There are many who

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could be made available for this purpose, and not many would be required. There are only fourteen divisions to be catered for, and one officer per division is really all that is essential. This officer would be under the orders of the C.R.E. and Adjutant, and would assist them generally in organizing and carrying out the training programme. He would be informed some weeks or months before camp as to which division he is to be attached to, and he could then get into close touch with the C.R.E. and P.S., and could probably get to know the unit officers as well. It is suggested that these officers could easily be supplied from Chatham, the R.M.A., and especially from the ranks of those whose time is spent in theoretical instruction or administrative services, who would probably benefit considerably themselves by a short period in direct contact with troops. The scheme is really as much for the benefit of the regular side of the Corps as for the T.A. Few regular officers understand very much about the T.A. units, the difficulties under which they labour, and the sacrifices of time and leisure they make in efforts to obtain adequate training with inadequate material, unfit and untrained horses, few facilities for practical experience, and lack of instructional staff. There can be no proper *liaison* until this lack of understanding is eradicated. The writers last year completed a camp in the positions of adjutant and attached officer, and can vouch for the keenness with which this scheme was accepted. The units concerned received with enthusiasm the suggestion that a regular officer should be attached to them to help, did everything in their power to further the success of the scheme, and certainly provided the attached officer with an extremely interesting and pleasant fortnight.

It is tentatively suggested that the scheme should go further, and that throughout the rest of the year a considerable amount of assistance could be given by officers and N.C.O.'s of regular units to the T.A. units in the same areas and commands. This is, however, beyond the scope of this short article.

Finally, the writers would like to call attention to the courses for T.A. officers at the S.M.E., though fully realizing that they are stepping in where the proverbial angels fear to tread. The S.M.E. messes generally are large, with an ever-changing population. This all naturally tends to the formation of interests, which are either rather self-centred, or which centre round the "batch"; but at the same time, it is essential to realize that the T.A. officer very largely depends on his course at Chatham for his outlook on the regular side of the Corps. This outlook is very much coloured by the way he is treated in the various messes, and if there were only a closer personal *liaison* between regular officers, especially those most junior, and the T.A. officers, with a fuller realization of the latters' point of view, there would be a greater mutual regard, and a deeper conviction that all ranks, whether regular or territorial, belong to the same Corps.

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# *THE NEXT GREAT WAR.*

*By* CAPT. B. H. LIDDELL-HART.

## I. SCIENCE AND MILITARY STRATEGY.

IN seeking to estimate the nature of the next great war, the course of our thought must inevitably reflect the progress of scientific invention. This development, whether for good or ill, is the supreme factor in modern civilization and is affecting the organization and mentality of national communities in such measure that it is only reasonable to suppose that the methods of war will reflect the ever-changing face of civil life.

The field of survey is so great that some bounds must be set on our researches for the purpose of the present study. Otherwise the problem appears almost too wide to tackle by any other method than the unrestricted imagination of a Jules Verne or an H. G. Wells.

This is the realm of possible scientific *discovery*. The future may undoubtedly bring to fruition the dreams of the sensational novelist —discovery in bacteriological and electrical science may lead to the wars of the future being waged by means of the germs, or the green, purple and other rays, lurid in hue and effect, which form the properties of the prophet-novelist. But for a reasoned attempt to forecast the nature of the next war we cannot rely on suppositional discoveries of such a revolutionary character. Scientific *invention*, on the other hand, is concerned with the evolutionary development of the powers and properties which are already known to us.

The restriction of our survey within these limits appears justified historically by the precedents of past wars. History shows us that no entirely new weapon has radically affected the course of any war ; that the decisive weapon in a war has always been known, if but in a crude and undeveloped form, in the previous war.

It is foolish, also, to leave out of account the natural conservatism and prudence of military hierarchies or the parsimony of governments in regard to expenditure on military experiment in peace-time.

Let us, therefore, meditate on the probable lines of development of existing means of war instead of launching out into fantastic speculations which may prove but chimeras in the desert of future war—futile of advantage for practical military needs. Such a study divides itself into two natural realms—those of strategy, which is pre-eminently the science of communications, and tactics, which is the domain of weapons.

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To put it more simply, strategy is concerned with the primary element, movement, and tactics with that of destruction—whether it be of the enemy's flesh or his will-power, the bodies of his troops or the nerves of his commanders and government.

### *A Means of Test for Military Truth.*

Having considered our potential opponents, we come to the kernel of our subject—the effect of scientific invention on our next major war, in regard both to strategy and tactics.

The common method in speculations on the future is to rely solely on imagination, swayed, possibly, by the personal prejudices and inherited ideas of the author. Such a method, though harmless in a Wellsian novel and all too common even in traditional military literature, is surely both vain and out of place in any study which aims at a serious military purpose and as a guide for rational thought.

We require some means by which we can test the various hypotheses and ideas which are advanced, so that we may co-ordinate them and classify them scientifically according to their several values.

In other words, the paramount need is for what may be termed a compass or test-tube for military thought. It would surely appear that such a scientific means of test may be found if we can establish the fundamental principles of war—those which history shows us have been proved true and immutable by the experience of all past wars.

Since the end of the last war there has been a general realization that the absence of such a synthesis of basic principles was the root cause of the failure, common to all the warring nations, to adapt without perilous delay the prevailing methods to the changes in the conditions and weapons. As a result numerous attempts have been made to formulate the essential principles. The present author has been guilty of one such attempt.

That at least an approximation to truth has been obtained is shown by the fact that in essentials nearly all these syntheses agree, the differences being mainly of terminology or degree of comparative value assigned to the respective parts of the table.

In order to avoid, or at least minimize, controversy, it is proposed, for the purpose of this study, to take as our means of test the table of principles set forth in the official *Field Service Regulations* of the British Army. Eight principles are listed: the principle of the Objective, for in every operation of war an objective must be determined and held in view throughout; the principle of the Offensive, which may be more simply termed "hitting"; the principle of Security, or guarding; the principle of Mobility, which is necessary both for successful hitting and guarding. The other

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four principles given are those of Surprise, Concentration, Economy of Force, and Co-operation.

Colonel Fuller has divided these principles into two groups, the first four being the "elemental" principles which are derived directly from the four main elements of war—mind, movement, weapons (*i.e.*, destruction), and protection (*i.e.*, maintenance against destruction). The other four he terms "accentuating" principles.

| | | | | |
|---|---|---|---|---|
| *Elements :—* | Mind | Movement | Weapons | Protection |
| *Elementary Principles :—* | Objective | Mobility | Hitting | Security |
| *Accentuating Principles :—* | Surprise | Co-operation | Concentration | Economy of Force |

Having thus got a table of fundamental principles, we can proceed to test all new ideas on armament, movement, and organization by means of it, although with reference to the probable conditions under which the latter will have to function.

In order to keep our survey within limits, we shall deal only with the two concrete elements, movement (or communications) and weapons, which are the basic factors in strategy and tactics respectively, and in this article with the first only.

### *Communications.*

As strategy precedes tactics in chronological order, let us first deal with the subject of communications and the effect on them of scientific inventions. Movement—a simpler word for communications—is of three categories—by land, sea, and air. These main categories may again be sub-divided—land-movement into track (road and rail), and trackless, sea-movement into surface and submarine, air-movement into heavier and lighter than air.

As they are to-day, what are the relative advantages of each? Let us examine these three physical elements and apply the test of our synthesis, for the sake of "economy of space" only mentioning those principles which are relative to the points under consideration. From the point of view of *mobility* air is easily first, land (rail) second, sea third, and land (road) fourth. For *surprise* movement, sea was first and land second, whether by rail or road—before the introduction of aerial observation. Now, so far, at any rate, as a European theatre of war is concerned, the surface of the sea has lost much of its advantage as a medium for surprise through secrecy. Moreover, it is the element which is least suitable for the attainment of secrecy through movement by night combined with concealment by day. Surprise by sea is, therefore, limited either to

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movement in submersible vessels, or on the surface at such a range that a complete " bound " can be made during the course of a single night. What regions are included in this definition? The coast of France, Belgium, and Holland alone. The Mediterranean also is ruled out by reason of the distance between our naval bases, should any Mediterranean power be included among our enemies. Nor even, were the Bosphorus held, could we reach any point on the Russian Black Sea *littoral*.

For *concentration*, and to a lesser degree for *economy of force* and *co-operation*, the sea remains supreme for long-range movement. So long as we do not lapse to a position of naval inferiority and so long also as we maintain the asset of our mercantile marine, we can best fulfil these principles strategically through the medium of amphibious operations. Sea transport still holds the palm for bulk capacity and simplicity of organization. *Security* is dependent on the command of the sea, and to a lesser degree, on command of the air.

Next, we come to the air. For *mobility*, this channel of movement is easily superior to any other, and its margin of superiority must inevitably increase rather than decrease, as it is immune from the effect of natural obstacles, while it enjoys a decrease of atmospheric pressure, which retards movement. In regard to *surprise*, at low altitudes air transport is the most difficult of any to conceal, but there is no reason why aircraft movement should not be carried out at levels which preclude observation from the ground under the normal climatic conditions which prevail in Europe. Further, the speed of aircraft is such that the need for secrecy in order to achieve *surprise* is considerably discounted. Being trackless, aircraft have a considerable advantage in regard to *security*.

Are we to assume that the air must necessarily become the sole medium for military movement? No, because there are certain inherent defects which threaten its otherwise preponderating advantages—viewed as a means of communication for the existing pattern of military forces. In the first place, aircraft have to descend at some time and their landing places are vulnerable, particularly if temporary sites in the zone of the armies. Secondly, the carrying capacity of the heavier-than-air type is still very limited, whilst the gas-filled airship, although at present rather better in this respect, presents too great a target surface. In other words, the essential requirement of *concentration* is wanting, which defect weighs down the scales against air transport.

Turning to the land, we realize that movement by rail is governed by the communications established in peace-time. These, among the Powers of Western Europe, are unlikely to undergo any extensive alteration for commercial purposes, whilst definitely strategic railways excite suspicion and thereby defeat their object so far as surprise is concerned.

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Russia, the one country affording scope for a commercial extension of the railway, is the least likely of possible Allies, while its distance from this country makes our use of such communications improbable, and discounts any consideration as regards the organization of our forces.

The railway, moreover, is of all means of communication the most difficult for secrecy, and most open to the operations of all branches of enemy intelligence. *Surprise* in *direction* or *time* is a virtual impossibility, and even in *quantity*, or concentration, increasingly hard to obtain with the development of observation from the air. Nevertheless, the railway, by reason of its transport capacity, remains at present the best medium for the achievement of *concentration*. In *mobility*, even in countries where the road system is highly developed, the railway is also far superior not only in regard to speed but because of its carrying capacity in proportion to space occupied. For *security*, road communication is a degree superior to rail, offering a more-easily concealed and more widely spaced target, a larger choice of alternative routes, and being more quickly reparable after damage has been inflicted. But if one transcendent lesson is to be drawn from the experiences of the last war, it is the inadequacy of either road or rail communication to cope with the requirements of modern armies. From the first German onset of August, 1914, to the final Allied advance of 1918, this lesson stands out above all others. Yet in neither of the cases we have mentioned were the difficulties in any considerable degree the result of hostile interference from the air—the trouble was from within rather than from without.

It is surely undeniable, however, that aircraft means of action must increase in range and effect, rather than diminish, with the passing years.

If this progress be axiomatic, then the nation which continues to organize its military communications on the basis of roads and railways is running for a fall.

What is the alternative? The condition common to both these means of communication is that they move along fixed tracks, which cannot be varied save after a long period of labour and preparation. The opposite method to tracked movement is trackless. There is already in existence a means by which the fixed and prepared track is no longer a necessity—the chain-track machine, such as the Citroen tractors which have recently conquered the Sahara.

Let us study this form of movement over land.

*Mobility*, so far as speed is concerned, seems at first to be inevitably worse than by road transport—the slowest of all existing means of communication. On a level and prepared surface there can be no question that, where equal motive power is employed, the wheeled vehicle must be faster than the chain-track one. If the power is

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increased disproportionately in the case of the latter machine, then on economic grounds at least the change is for the worse.

But are the majority of roads level or of a good surface? Far from it! Moreover, this defect will be increased in most of the regions where our army is likely to operate, both by their existing shortage and by the heavy traffic caused by military movements. If we regard Russia as a probable enemy the weight of this consideration is multiplied. On roads that have been cut up or are little better than tracks, the caterpillar vehicle scores in speed every time over the wheeled vehicle. In the next place, the roads, of Europe particularly, are far from level, considered as a whole. On gradients, the caterpillar machine with the new sprung track is actually faster than the wheeled vehicle of equal horse-power; the feet of the track grip the surface better than the wheel, and have the further advantage that they damage the surface less—a factor of immense importance, not only for war but also for peace purposes.

Therefore, for the conveyance of loads the use of the caterpillar lorry is better *economy of force* than that of the wheeled lorry, for its margin of superiority on poor surfaces is immense, whilst on good surfaces, except in flat country, its lesser speed in proportion to power output on the level is balanced by its greater speed per horse-power in undulating country. The principle of *economy of force* tells us that a vehicle which has a definite commercial value has a decided advantage from a military standpoint, as its chances of mechanical development are greater and its expansion in emergency assured.

For *surprise*, the fact that the caterpillar vehicle can move off the roads defeats the enemy's *information* and establishes its superiority over the wheeled vehicle, which is of necessity tied to the arteries of traffic—these are shown on the map and can be kept under observation from the air.

In *concentration*, the caterpillar machine solves the problem of congestion, which has always been the brake on concentration of force at the decisive point.

It is not suggested that roads will be abandoned—so long as good roads exist it is more advantageous to use a smooth surface than a broken one. But the chain-track does enable the concentration of traffic on any particular line of movement to be multiplied, not merely double or quadruple, but tenfold, twenty-fold, or even more. Moreover, even on the road the volume can be increased. The weight which can be carried in wheeled transport is regulated by the pressure per square foot which the road surface can support without damage. A three-ton lorry is the largest which normal roads can carry, and even then the injury is soon manifest. Thus on 100 yds. of road space only some 24 tons can be borne by wheeled

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lorries, whereas by using 24-ton caterpillar lorries approximately 170 tons could be carried with an actual reduction of pressure per square foot on the surface. This reduction of road space required not only multiplies concentration, but necessarily increases the *mobility* of a force.

*Security* is made possible of achievement in the case of chain-tracked transport, for on the approach of danger from the air it can move off the road and seek shelter or decrease the target by dis-dispersion—possibilities which are denied to the present lorry, with its one-dimensional power of movement. The former machine could, moreover, afford to sacrifice a fraction of its weight-carrying capacity in order to protect directly, by armour plating, the vital parts against any injury except that inflicted by a direct hit.

### *Future Development.*

In what respect is progress likely in these various means of movement as the result of scientific invention? If our speculations are to have any practical value, it is useless to indulge in flights of the imagination which take no account of the many problems of science still to be solved. We should confine ourselves to improvements of detail in means already existing, keeping our feet on the solid rock of truth as it is known to-day, rather than assuming, as certain, changes which involve a revolution in principle.

On the sea the large capacity submersible is a proved possibility. It does not, however, seem likely to supersede the surface ship as a general means of transport, as the cost and space wasted in making a ship submersible is not economic, and holds out no compensating advantages for mercantile purposes. As such vessels will necessarily be restricted to use in war, the number of them will, owing to financial causes, be small. They will, therefore, be available only for the conveyance of small striking forces against special objectives.

On land, neither railway nor road transport offers a prospect of radical development from a military point of view.

The cross-country machine capable of moving on and quitting the roads at will is an established fact and only requires improvements of detail. One line of development is a machine which will combine wheels with a caterpillar track for alternative use. More probable is a further improvement in springing, which will render feasible the use of an ordinary motor-lorry engine and at the same time enable the machine to move on roads at a speed equal to that of the present wheeled lorry and without appreciable increase of wear on the road surface.

In the air the airship, with its huge volume of gas-filled envelope in proportion to its small lifting power, is uneconomic.

In *mobility*, the aeroplane will still make progress. In *surprise*

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also, both by reason of its speed, and by the use of protective colouring and engine silencers. Its *security*, however, is hampered by the laws of gravity. Armoured protection can only be gained at the expense of carrying capacity, *i.e.*, *concentration*, and even then is only possible within narrow limits. Practical experiments on present lines do not augur well for the production of the giant air liners beloved of the imaginative novelist.

Our conclusions, then, in regard to the strategic communications of the Imperial Military Forces, can be briefly summarized.

As an island state the first stage of our communications will still be by sea, in surface-travelling ships. Submersible transport can however, be used to launch by surprise small and specially-composed striking forces at suitable objectives.

The second stage of our communications, on land continents, should no longer be based primarily on the railway, but on caterpillar transport. *Mobility* indicates that the latter should move on the roads, provided that sufficient are available. *Surprise* indicates that movement should, so far as possible, be by night "bounds." *Security* tells us that caterpillar transport will quit the roads and move across country on the approach of enemy aircraft and on reaching the zone where contact with the enemy land forces may be anticipated.

Aircraft transport may become a useful auxiliary, like the submersible ship, but no more, so long, at least, as ground troops remain a staple part of the national forces.

## 2. Science and Tactics.

It is proposed in this second part of the article to discuss the element of weapons, which is the main constituent of tactics, and to discover, as far as may be, the probable development of weapons and their respective values, as affected by the progress of scientific invention.

## The Scientific Development of Weapons in Relation to the Existing Arms of the Service.

### 1. Infantry.

At present the infantry unit resembles the stage brigand—with weapons of different kinds and patterns sticking out of every portion of his anatomy.

To its staple weapon, the rifle and bayonet, have been added the light automatic, the machine-gun, the grenade—hand and rifle, explosive and smoke, the light mortar, and in some armies the accompanying gun, which is also advocated for our army in the form of pack artillery.

Is it advisable to utilize so varied an assortment of weapons?

The keynote of the value of infantry is *mobility*, or rather, loco-

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mobility—its still unique power to move in, over, and through every yard of any given locality. All these new weapons certainly add to the hitting power of infantry; but do they detract unduly from its mobility?—that is the test question. If they reduce that essential mobility to an appreciable degree, they discount the value of the increase in fire power. Could fire-power alone win victory there would be no place for infantry even in the armies of to-day; the auxiliary arms can supply a far more potent fire. But infantry can carry its fire to close quarters and supply that tangible human threat which makes the enemy run.

Important as is fire in paving the way for the advance, it is in forward movement that the decision rests. The legs of the infantry are as essential on the battlefield as their "arms."

Therefore we surely ought not to allot to infantry weapons which may induce it to rest content with firing on the enemy from more or less stationary positions.

If we apply our test of *mobility*, the machine-gun, the light mortar, and the accompanying gun are surely condemned at once as infantry offensive weapons. Either they fall ever further to the rear during the infantry advance or the pace of the real infantryman has to be checked constantly in order not to outstrip them. In the former case they are valueless assets to the infantry; in the latter case they render the infantryman bankrupt of his mobility.

The tests of *surprise* and *security* confirm this conclusion. These new weapons attract far greater attention and present a far larger target than the "pure" infantry.

Depending for movement on limbers, pack mules, and—in the final stage—man-handling, they cannot afford the direct protection of armour, while at the same time they cannot avail themselves of the indirect protection of ground cover to the same degree as the infantry.

The principle of *economy of force* tells us that our organization should be as flexible and interchangeable as possible for tactical efficiency. Weapons which lead to dispersion of effort and wide variations of mobility are condemned by this test.

Internal *co-operation*, *i.e.*, within the battalion, always one of the chief problems of battle, becomes far more difficult when the fractions which have to co-operate vary in armament and mobility.

The light automatic and the grenade suffer from the same disabilities but to a lesser extent. The danger in the case of the grenade can be avoided if the quantity issued to infantry is reduced to very small proportions. To do this in the case of the explosive grenade is to make it a negative asset, and therefore it should be reserved solely for the clearing of fortified defences. The effect of the smoke grenade is, however, of such value in proportion to its bulk, that it is economically sound to carry a few for action even in open warfare.

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Owing to the usure of ammunition by a light automatic, the fact that it requires a minimum of three to four men for its service, and the appreciable loss of mobility entailed by it, it is open to question whether it is superior to a section of well-trained riflemen. A reduction in weight that would make it more handy is a likely step in development, but this improvement would not justify its issue as an individual weapon owing to the rapid expenditure of ammunition.

## 2. Cavalry.

The arguments for and against the retention of cavalry have been discussed at such length since the war that to recapitulate them would only be wearisome.

Apply the test of *protection* (*i.e.*, *security* to themselves), and the answer is so transparently clear that for a civilized war it is decisive. Cavalry in bulk are so vulnerable a target that they cannot exist on a modern battlefield. On the one hand, they cannot avail themselves of the direct protection of armour, nor, like the infantryman, can they make use of the indirect protection of ground. The cavalry charge, therefore, is dead—at least against efficient troops.

Further, as the use of any instrument in war depends on the existence in peace of its means for production, the horse must eventually become extinct in course of time, as it is being rapidly ousted for all commercial purposes. The horse cannot be bred rapidly in large quantities in emergency as can be manufactured mechanical weapons and means of transport.

Although, however, the supply is decreasing and will necessarily continue to decrease with the years, the progressive release of horses from the artillery and transportation services will ensure sufficient for the possible needs of cavalry for some period yet.

As cavalry are clearly obsolete for *hitting*, is there sufficient reason to justify their retention for the *security* of the army?

For long-distance and large-scale reconnaissance aircraft have displaced the cavalry body. But for close and wooded country the cavalry trooper moving on the ground can obtain detailed information denied to the observer above.

The obvious solution to the problem we have propounded is that a certain proportion of cavalry should be retained for this purpose until such time as the locomobility of the caterpillar-tracked machine is fully equal to that of the horse in every respect.

But the obvious solution is not necessarily correct. The man on foot is necessarily more loco-mobile than the man on horseback. The latter's superiority rests only in his *speed*, which is but a part of *mobility*.

A small and light chain-tracked machine could be produced even now which would move over any kind of ground traversable by

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cavalry, except dense woods and hill tracks. If the general mobility of such a machine is greater than that of the cavalryman and the loco-mobility of the man on foot is similarly greater than that of the cavalryman, the deduction is surely that the sum of the two is greater. Any reconnaissance, therefore, could surely be carried out far quicker, and with at least equal results, by a chain-tracked machine, whose crew could leave their machine when necessary and carry out the detailed exploration on foot, than by the cavalryman. Moreover, the need of the latter for a horse-holder when he dismounts for reconnaissance over very broken ground infringes the principle of *economy of force*.

### 3. ARTILLERY.

What are the probable developments of the artillery in *mobility*, *hitting* and *security*? Let us consider this arm in two categories —field artillery, including both light and medium guns; and heavy artillery.

#### (*a*) *Field Artillery.*

These can only improve in mobility by being motorized, which implies that they are to be hauled by a caterpillar tractor, mounted on or carried in a caterpillar transporter, or fitted in a tank.

An increase in mobility will automatically increase the power of *concentration*.

Neither of the first two methods will affect indirect *security* by secrecy, but the third will diminish the possibilities of concealment by ground.

Direct *security* by protection while in movement, is only possible, by fitting the gun in a tank. The latter method loses the protection given by an emplacement, but compensates for this loss by the double security given by armour and by the fact that it is a moving target.

Finally, this method enables the gun to dispense with the necessity for being guarded, or secured, by another arm. The abolition of the need for an infantry escort or screen in front of the gun simplifies the problem of *co-operation*, the most difficult of all principles to fulfil in war.

*Security* against the enemy's information is likewise far easier to achieve if the gun is constantly changing its position, as it will if fitted in the tank, or to a lesser degree if mounted on a transporter.

#### (*b*) *Heavy Artillery.*

As this form of artillery is already moved mechanically, an appreciable improvement in *mobility* cannot be anticipated. *Hitting* power is the only factor susceptible of material progress.

The question is rather as to the value of heavy artillery. First, let us consider *hitting*. The aeroplane can hit with equal effect, but

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not so rapidly or frequently. It can also hit a moving target with greater acuracy. If the armies of the future are to be composed of mechanically-moved units, the heavy gun loses its target. In that case the heavy gun will be relegated to the bombardment of fixed fortified bases or towns, as it was in the past ; it will lose its utility with field armies.

Secondly, *security*. The heavy gun cannot hit its aggressors, the aeroplane and, possibly, the tank, while they can hit it with impunity once they discover its location. By reason of its size, it is difficult to secure it against enemy information and blows.

## 4. Tanks.

Let us now test by our table the tank of the modern type, with its sprung track, maximum speed of 28–30 m.p.h., and an average speed across country of 15–20 m.p.h.

In *mobility*, the tank has a vast margin over all other arms except cavalry, which, however, is placed out of court by reason of the fact that it can never use its speed against modern fire-arms.

In *secrecy* (for *surprise* and *security*) the tank is inferior to the other arms. Its speed, combined with the power of discharging smoke-clouds, redresses this defect to a considerable degree, but does not entirely balance it.

*Hitting* power demands a more detailed examination and must be weighed with *concentration* and *economy of force*. The economic unit of infantry which corresponds approximately to the tank is the platoon, the replacement, repair, and petrol cost of the former being balanced by the fact that the pay, food, and maintenance of its crew is but a fraction of that of the platoon. The infantry platoon has an armament of two light automatics and 24 effective rifles, even including section commanders and the spare men of the light automatic sections. To this must be added a half-share in a machine-gun and an eighth share in a light mortar. Assessing the tank armament at the minimum of one 6-pounder gun and three light automatics, the fire-power of the tank is seen to be clearly superior, especially when it is remembered that the tank can fire during movement, whereas the platoon has its fire-power reduced by one-half, at least, owing to the need for covering fire.

*Co-operation*, again, is demonstrably simpler in the case of a self-contained tank than between four infantry sections.

*Security* likewise gives the tank a clear margin of superiority over all arms, for it alone can carry direct protection by armour. The field gun's armoured shield is not all-round protection, nor is it available during movement.

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## 5 AIRCRAFT.

Although these are at present organized as a separate service, apart from the military forces of the nation, they must be included in any survey, as they act over land and, therefore, exert a profound influence on the action of the land forces.

Let us, therefore, consider aircraft strictly in regard to their operation against the land forces.

In *mobility* they have a tremendous superiority over all the other arms.

In *secrecy* (for *surprise* and *security*) they are at an equal inferiority tactically, for, save in exceptional conditions, early warning of their approach is obtainable. Against arms which have the power of quickly sheltering, like infantry, under cover of ground, or, like tanks, by rapidity of movement and the use of smoke-screens, this lack of secrecy of approach is a disadvantage.

In *concentration* of hitting power, aircraft are difficult to assess. Their development is, however, subject to restrictions, due to gravity, from which the ground-moving arms are free.

In *co-operation* they share in the advantage of the tank.

In *security* they are, at present, most vulnerable save for the indirect security afforded by their mobility. The armoured aeroplane is, however, already in course of development. But this protection, to whatever degree it is increased, will always be subject to the limitations of gravity. Here lies the joint in the aeroplane's harness.

## 6. THE GAS WEAPON.

No investigation of future war can overlook this weapon, which cannot be abolished by the decrees of Leagues and Conferences.

*Economy of Force.*—Its speed and economy of manufacture is superior to that of any other weapon, because it is the only one which is a commercial product, manufactured from chemicals which are an essential requirement of peace-time industry. In emergency, therefore, there is no need for the tardy establishment of special plant.

*Mobility.*—In speed of discharge it is necessarily supreme, because it is continuous, which not even the quicker-firing missile projector can be.

*Surprise.*—In secrecy of manufacture it is unequalled, because its constituent chemicals are commercial products, and can, therefore, defeat the enemy's *information*. All other weapons are, in part at least, destined for a definite military purpose, and so their production in quantity cannot be kept secret except at the expense of *concentration* of hitting effect.

In *secrecy* of discharge it is paramount, because it is noiseless, and, if used at night or combined with smoke, invisible.

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In *hitting power* and *concentration* it is supreme, firstly, because its volume is infinitely greater than any projectile—the most rapid-firing missile projector, the machine-gun, can only fire 600 bullets in a minute, whereas the gas cylinder can discharge millions of invisible bullets or molecules in the same time; secondly, because, unlike any projectile, it leaves no voids unswept in its beaten zone; thirdly, because it requires no skill in aiming and is therefore unaffected by the emotions or physical deficiencies of the firer.

*Security* serves to emphasize the superiority of gas, for an antidote can only be produced by those who know its actual constituents. Therefore, the users of a new kind of gas possess an almost certain chance of effecting a surprise against a totally unprotected enemy, whilst they themselves have a complete immunity from danger from their own weapons. The indirect value of this immunity is even more far-reaching than the direct, for their progress is in no way hampered by the fear of masking fire or by the curtain of an artillery barrage. Thus the dreaded interval between the lifting of fire and the actual clash of the troops is abolished.

It may be argued that we cannot consider the employment of gas, because the moral sanction of the peoples is refused to it. But if it be demonstrated that gas is more humane than any missile weapons, because it can achieve its object—the capitulation of the enemy—equally well in a non-lethal form, this moral prohibition on its use will be removed.

## The Elimination of Traditional Arms.

Having surveyed the probable developments in weapons and analysed the qualities of each, let us endeavour to draw conclusions from them. To do so, let us consider the various arms of the service and their weapons in relationship to each other. As gas is established in our mind as the weapon of the future, let us make it the starting-point of our comparison. How can the respective arms protect themselves against its effect? Aircraft, by rising above it; tanks, by being air-tight and producing their own oxygen inside whilst being impervious to the outer atmosphere; infantry, cavalry and field artillery by the use of some form of respirator. A respirator is only proof against known kinds of gas; it cannot be worn for long without incapacitating its wearer from active exertion; it cannot protect the whole body, unless it be transformed into a complete diver's suit, in which movement would be almost impossible. If a man cannot move freely, he cannot fight. If a horse cannot move, what use is his rider? If the artilleryman cannot serve the gun freely and the gun is immovable, field artillery is useless. Therefore, we are left with the aeroplane and the tank as the only effective arms, if gas becomes a standard weapon.

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This conclusion is reinforced by the fact that, as gas requires a projector, the latter needs to be carried. To move it mechanically is obviously better in every respect than to move it by muscular power—for *mobility*, *surprise*, *concentration*, *security* and *economy of force*.

Given that the factor of bringing gas to its place of discharge is equal, cloud gas is infinitely superior in effect to shell gas. This consideration rules out the artillery as its means of projection.

But are even two separate arms necessary? Cannot the use of aircraft dispense with the need for tanks or the reverse?

No, because they act in different elements, possess different qualities and limitations, and neither is decisively superior to the other when they meet in direct opposition.

In offence the aeroplane is invulnerable, so long as it remains at a sufficient altitude. But from this height it can only hit the tank by a rain of gas. Against this weapon, infantry, cavalry, and artillery can only protect themselves fully at the price of their mobility and hitting power—in which case they have no value. The tank, however, can be made air-tight and defeat the purpose of the aeroplane. Therefore the aeroplane is forced to descend very low, if it is to have a chance of hitting by bomb or bullet so small and rapidly-moving a target as the tank. If it flies low, the tank can hit back effectively. The odds in such a contest would be on the side of the aeroplane because of its infinitely superior speed and its power of three-dimensional movement, but they would not be long odds, because the effect of gravity weights the scales against the aeroplane and in favour of the tank in the struggle to increase *concentration* of fire-power and *protection* by armour. In its turn the tank has a clear margin in counter-offence by attacking the landing and refilling grounds of the aeroplane. The latter is severely handicapped here, because it can only conduct its defence from the air.

These bases of the aeroplane can, however, be fortified against the tank's attack. Here we discover the only future use for infantry and artillery—as the stationary defenders of these fortified bases.

Therefore, when gas is installed as the primary weapon, our deduction is that the forces which act over the land will be composed principally of aircraft and tanks, with a certain proportion of heavy artillery as fortress destroyers, and of infantry, armed with super-heavy machine-guns firing armour-piercing bullets, and light artillery as fortified base-defenders.

Let us assume, however, that the warring powers will abide by the wishes of the League of Nations and Disarmament Conferences, and that they will not employ the gas weapon. To what extent will our deductions be affected? To solve this question let us propound, and try to answer, a series of questions.

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1. What are the foes of infantry and how can it act against them? First, the *hostile infantry*—whose resistance is based mainly on machine-guns and light automatics. How does it counter these? Not by its own fire so much as by the aid of artillery and tanks. Infantry is only self-sufficient when it has passed through the organized screen of enemy fire and got to grips with the hostile infantry.

*Co-operation* between two different arms is so difficult in practice that a single arm is clearly preferable if it can act as effectively. The only part of the infantry attack which the tank cannot execute with infinitely greater efficiency and economy is the final phase of digging the enemy out from their earths—natural or artificial.

Second, the *enemy artillery*—whom it is usually powerless to reach and whom it can only counter by the aid of other arms; unnecessary problem of co-operation once again.

Third, the *enemy tank*. Infantry cannot act offensively against the tank, because the speed of the latter can always enable it to avoid conflict at will. Infantry's only direct means of defence against the tank are by anti-tank accompanying gun or machine-gun, or by the land mine.

If either of the former category of weapons is used, we are brought back to the old struggle of projectile *v.* armour, with the odds all in favour of the tank, because, being mechanically moved, it can increase its ratio of *protection*, whereas the infantry anti-tank weapon, being muscle-moved, cannot increase its ratio of penetrative power without becoming immobile. If it becomes immobile, it is useless to infantry in the field; if it adopts the other alternative and becomes mechanically moved, it is no longer an infantry weapon, but a tank.

As regards the land mine, the only form which can be portable and rapid in employment is one which is small and visible; even then it suffers from the grave defect that it negatives *offensive* action by infantry. Such a mine can be exploded harmlessly by some form of tender in front of the tank. If a large land-mine is used for buried systems, it is only available for restricted areas and in stationary defence, a confession that infantry are only fortress defenders.

Fourth, the *enemy aeroplane*. Infantry in the open have no effective means of hitting the aeroplane unless it comes low. The aeroplane, on the other hand, can remain at a moderate height and by bomb and bullet inflict serious injury on its helpless victims, who can only hope to lessen, not to escape, casualties by dispersion or by turning themselves into human moles.

Thus we are forced to the conclusion that, as infantry cannot effectively *hit* any of its opponents except by co-operation with other arms—a co-operation to which it contributes no assets—its

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value in war vanishes, except for two special functions. These are, first, as the defender of positions fortified by nature or art, and secondly, as the "ferret" to eject from these positions its opposite number.

It is needless to consider cavalry, for it suffers from all the disabilities of infantry, save only that by reason of its speed it has an increased chance of escaping from the tank, but less from the aeroplane because of the greater target which it offers.

2. What are the foes of field artillery and how can it act against them?

First, the opposing artillery—for which it needs the *co-operation* of aircraft for information. Aircraft can destroy artillery, which cannot—as does the tank—escape by speed, without the co-operation of any other arm.

Second, the infantry. While artillery suffers less risk from infantry, the last war proved that it is less effective than the tank in destroying infantry. If this was so in a war of positions, how much greater the disparity in a war of mobility, where the infantry can hope to escape artillery fire by movement, but never the tank.

Third, the tank. The field-gun was undoubtedly the most effective anti-tank weapon of the last war, but it is questionable whether, in the later stages, it destroyed more tanks than the latter destroyed guns. Such successes as it obtained were against tanks moving at not more than 3 m.p.h. What chance would it have against a tank zigzagging at a speed of over 20 m.p.h.? If it cannot hit, it will be hit. To have any chance the gun must have a fixed mounting with all-round traverse—in which case it is no longer a field weapon, unless it is fitted on a tank! The latter method is the obvious solution, for only a weapon of equal mobility can compel the tank to come to action.

Finally, we come to the aeroplane and the tank, which have already been considered in their relation to the other arms and to each other. How and with what weapons will aeroplane fight aeroplane and tank fight tank? Not with gas, because both the aeroplane and the tank can be made gas-proof. Rather, with armour-piercing projectiles. Both machines are independently moving and fighting self-contained units, fulfilling in the higher degree the principles of *hitting power*, direct *security* by armour, *economy of force*, facility for gaining the *objective, surprise, mobility*, and *co-operation* both between the parts and from above, which here signifies that the commander has the power of instantaneous control. What established type of fighting organism already possesses the combination of these qualities? The warship.

Thus the tactics of tank *versus* tank must, of necessity, conform in principle to those of naval war, while overhead Tennyson's "Airy

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navies grappling in the central blue" find literal and not only figurative fulfilment.

If, therefore, we have at our disposal for use on land a machine capable of fulfilling the complete rôle of a self-contained fighting organism, which can dispense with the need for external *co-operation* —that thorniest of problems—is it a rational policy to retain arms which are essentially incomplete?

To do so would be equivalent to the folly of sending a thousand swimmers armed with grenades and supported by floating batteries to attack a man-of-war. Everyone realizes the farcical nature of this suggestion. Is there not a want of common-sense in the common failure to grasp the superiority of the tank over an amalgam of infantry, cavalry, artillery, and infantry-bound tanks—the latter like mongrel curs snivelling at the heels of a stout and sluggish dowager instead of like hounds on the scent of their quarry.

## Summary.

The sum of our deductions is clearly that military operations in the future, the exact date being still indefinite, will be carried out almost exclusively by fleets of tanks and aircraft which will be maintained by communications based on the caterpillar tractor, with the aeroplane transporter as an auxiliary or secondary line of supply. Under these conditions heavy artillery and infantry will alone survive of the other arms, the former functioning again in the original defensive rôle of garrison artillery, whilst infantry will become a species of "land-marines" for the defence of fortified bases and to be discharged as "landing" parties, from the bowels of a tank fleet, for "ferret work" against suitable objectives. But to suppose that this metamorphosis from traditional armies will be accomplished as by the wave of a wizard's wand betokens an ignorance of the slow fruition of all new changes throughout history, due to the natural conservatism of the military masses even more than that of the leaders. When, as at present, this conservatism is reinforced by the most severe financial stringency, we must realize that "axes" are more probable than "wands" and have a keener edge. The consummation of the common-sense pattern army which we have sketched is therefore likely to be a slow process, comprising a series of limited "bounds."

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## *REINFORCED BRICKWORK.*

*By* CAPT. T. W. D. MILLER, M.C., R.E.

*Description.*—These notes are collected from work done in the erection of an Officers' Hostel at Chaklala, near Rawalpindi. This building was originally designed for a single Allahabad tiled roof over a jack-arch ceiling, while the verandahs were to have reinforced concrete roofs. The A.C.R.E. considered that the appearance of the rooms would be much improved by the use of a flat ceiling; and that cost would be reduced by employing reinforced brickwork in the verandahs, not only in the flat roofs but in the bressumers.

The idea is the same as in reinforced concrete, the tension stresses being taken by steel bars in the joints, while the compression stresses are resisted by the brick in cement, which here takes the place of the mixture of broken stone, sand, and cement used in concrete. The system was used on a large scale in the erection of Government buildings at Patna by the P.W.D.

Excluding temporary roofs of mud on reeds and matting and semi-permanent roofs of mud on planks, there are four types of flat roof for permanent buildings in India.

1. Tiles 12 in. long by 2 in. thick, set in lime, covered with mud or lime concrete and carried on either wooden joists or steel beams.
2. Reinforced concrete.
3. Reinforced brickwork.
4. Cement concrete on jack-arches.

Considering the first alone, it makes a good roof for servants' quarters; it is cheap and cool; the mud, however, wants constant attention, and even the lime concrete is washed away at times; wood is always liable to attack by white ant or rot, and steel beams only 12 in. apart are expensive; both wood and steel require periodical oiling or painting.

The disadvantages of reinforced brickwork in comparison with reinforced concrete may be stated as:—

(*a*) Comparatively few variations, *e.g.*, a slab can only be 3-in. $4\frac{1}{2}$ in., 6 in., $7\frac{1}{2}$ in. or 9 in. thick.

(*b*) Lack of flexibility, *i.e.*, the bars must be $4\frac{1}{2}$ in. apart in a 3 in. slab, and 3 in. apart in a $4\frac{1}{2}$-in. slab. The size of the bars must be kept low or cement is wasted in the joints. Waste

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of iron is probable, for the spacing cannot be varied as in concrete, and English $\frac{7}{16}$-in. and $\frac{9}{16}$-in. bars are not always obtainable in India.

(*c*) Possibility of cheating on iron, as each bar is placed separately and hence the iron framework cannot be viewed and passed as a whole, before the laying of the bricks is started.

(*d*) Waste of cement by careless workers, who let the joints get too big.

The advantages appear to be :—

(*a*) Economy in cost.

(*b*) Centring may be made lighter, as there is no ramming ; the face need not be so highly finished, and the joints need not be so close.

(*c*) More fool-proof, especially as the masons are accustomed to lay brick floors ; and as there is less likelihood of the reinforcement being displaced during laying.

(*d*) For beams no side-centring is required.

There are, of course, local considerations. At Chaklala bricks are very cheap (Rs.14 8an. per thousand) while good stone has to be brought 20 miles by rail, and costs Rs.9 4an. per 100 cub. ft. delivered on siding in $1\frac{1}{2}$ in. cubes ; it has then to be broken to size for reinforced concrete. The method seems better suited to an Indian workman who likes to work squatting, and does not make a success of ramming.

*Erection.*—The ceilings were erected as continuous spans from wall to wall, supported at intermediate points by the trusses, which were at 10-ft. spacing; the slabs varied from two spans in the residentia quarters to five continuous spans in the dining-hall. The tie-beams of the trusses were formed of two channels (3 in. by $1\frac{1}{2}$ in. or 4 in. by 2 in.) back to back, above which the ceiling went. The tie-beam, which thus projected through the ceiling, was boxed in with planking for the sake of appearance. See *Photo* F.

The system of laying was as follows :—The rods were bent to shape on a template on the ground, and the ends bent over to form a hook. After the centring had been fixed, a steel bar was placed over the supports at each end of the slab and the rods were threaded on these. After a course of bricks had been laid, a rod was pushed against this, and fixed at its proper height by a couple of wooden wedges. A number of bricks were then laid, thus permanently fixing the reinforcement, after which the wedges were withdrawn and the course of bricks completed.

The lower side was usually coated with lime plaster for appearance, the upper side of the ceilings was left rough, but the upper side of the verandah was brought to a plane surface with a skin of cement : this formed a waterproof coating.

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The centring was left in position for ten days at least, and thereafter no one was allowed on the completed work for another week.

All roofs exposed to the sun were made in sections of about 20 ft., separated by $\frac{1}{2}$ in. expansion joints. These spaces were covered by half-round Allahabad tiles.

*Calculations.*—The system adopted is the same as for reinforced concrete: the safe stress on brickwork in cement being taken as 600 lbs. per sq. in., while steel is only taken as at 14,000 lbs. per sq. in., as a precaution against the use of inferior steel.

As shown on page 16, *Reinforced Concrete*, Part II, when brick and steel are equally stressed:

$$n' = mr\left\{\sqrt{1+\frac{2}{mr}}-1\right\}.$$

See *Sketch* II.

It has been found advisable, at least for a slab with its small depth, to have not less than one per cent. of reinforcement. Hence

$$n' = \cdot 418 \text{ and } 1-\frac{n'}{3} = \cdot 861.$$

The moment of resistance of the steel is given by Equation 4, Appendix II, *Reinforced Concrete*.

$$T = tr\left(1-\frac{n'}{3}\right) bd^2,$$

which, where $r = \cdot 01$, $t = 14{,}000$ lbs. per sq. in., and $\left(1-\frac{n'}{3}\right) = \cdot 861$,

$$\text{gives } T = 120{\cdot}5\ bd^2.$$

Similarly, the moment of resistance of the concrete is

$$c = \tfrac{1}{2}\ c\ n'\left(1-\frac{n'}{3}\right) bd^2 = 108\ bd^2.$$

The lower value (108) must be taken in calculations.

Similarly, the constant for ·8 per cent. steel is 98.

Consider the roof of a verandah, 10 ft. wide, say, 10·5 ft. for calculations. See *Sketch* I. Take a 14-in. strip, equal to 4 bricks and 4 joints. Assume $4\frac{1}{2}$-in. depth is required.

Load per sq. ft.

| | | | |
|---|---|---|---|
| Brickwork in cement | $\frac{3}{8} \times 120$ lbs. | = | 45 lbs. |
| Cement plaster | ... ... say, | = | 1 lb. |
| Occasional load | ... ... | = | 20 lbs. |
| | | | 66 |
| | | say, | 70 lbs. |

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Load on 14-in. strip.

$$=\tfrac{7}{6}\times 70\times 10\tfrac{1}{2} \quad =857 \text{ lbs.}$$

$$B=\frac{WL}{8}=\frac{857\times 10\cdot 5\times 12}{8}=13{,}500 \text{ in lbs.}$$

$$M_R=108\ bd^2 \text{ and } b=14$$

Hence

$$d^2=\frac{13500}{108\times 14}=8\cdot 9$$

$$d=2\cdot 98 \text{ in.}$$

Allowing $\frac{1}{2}$ in. for cover, we get $3\frac{1}{2}$ in., hence $4\frac{1}{2}$-in. thickness must be used.

Amount of steel at 1 per cent.

$$=14\times 3\times \tfrac{1}{100}=\cdot 42 \text{ sq. in.}$$

This is in four bars, each of which must be ·105 sq. in.: hence one $\frac{3}{8}$ in. bar at ·1104 sq. in. in each joint will do.

For the bressumer take a continuous beam over three spans, each of 10 ft., carrying verandah roof taken above. Assume a section of $7\frac{1}{2}$ in. by $10\frac{1}{2}$ in. Load, 66 lbs. per ft. sup. Take width of verandah 10·5 ft. to allow for projection. Allow ·8 per cent. of steel.

Then load due to roof

$$=\tfrac{1}{2}\times 10\times 10\cdot 5\times 66 \quad =3465 \text{ lbs.}$$

Weight of bressumer—

$$=10\times\tfrac{5}{8}\times\tfrac{7}{8}\times 120 \quad = 660 \text{ lbs.}$$

$$4125 \text{ lbs.}$$

The maximum bending moment in this beam is $-\frac{WL}{10}$ over central supports.

Hence

$$B=-\frac{4125\times 10\times 12}{10}$$

$$98\ bd^2=\frac{4125\times 10\times 12}{10}$$

$$d^2=\frac{4125\times 10\times 12}{98\times 10\times 10\cdot 5}=47\cdot 71$$

$$d=6\cdot 90 \text{ in.}$$

Hence $7\frac{1}{2}$ in. by $10\frac{1}{2}$ in. beam is suitable.

Area of steel $=10.5\times 6\cdot 9\times \cdot 008=\cdot 58$ sq. in.

There are two joints, hence a $\frac{5}{8}$in. bar at ·3068 is suitable.

Similarly, in the end spans the maximum bending moment is $\frac{2}{25}$WL, and two $\frac{9}{16}$-in. rods will do; and in the centre span $B=\frac{WL}{40}$: two $\frac{7}{16}$-in. rods will do.

This bressumer is illustrated in *Sketches* IV and V.

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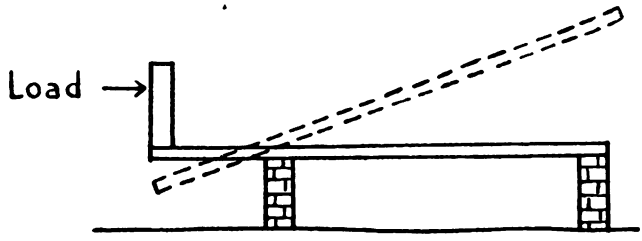
*Testing.*—At present no accurate results for deflection under load are obtainable. At Patna the beams were tested to destruction and failed in the tension flange.

Some figures are given in the attached *Table* (p. 115). All the beams tested at Chaklala cracked along the longitudinal joints, apparently due to failure in tension or in adhesion. I was not very satisfied with the mortar, but at that time no testing machine was available.

An attempt was made to test a cantilever, with the idea of forming a sun-shade. There was some doubt if this would stand a load. The beam was of 10-ft. span with a cantilever of 3 ft. The free end of the cantilever was loaded with bricks as high as the staging would allow, but no sign of fracture was observed. The beam was then left for the night under load; something arose to upset the equilibrium, and the load on the free end lifted the inner end of the beam from its seating, the outer wall forming the fulcrum. Of course, as soon as this happened, the position of the points of contra-flexure shifted and the beam collapsed.




It would be very desirable if instruments could be obtained to take accurate measurements of the steel during test, as this would enable definite rules for the investigation of these beams to be deduced.

*Cost.*—Taken from bed-sitting room. Area of ceiling, 21 ft. 9 in. by 16 ft. 9 in. = 364 sq. ft. Reinforcement parallel to long side of room, mortar 1 : 2.

I. *Materials.*

(*a*) Iron.

| | |
|---|---|
| α. $\frac{3}{8}$-in. bars for reinforcement $2 \times 54 \times 12 \times \cdot 376$ | 487 lbs. |
| β. $\frac{1}{2}$-in. bars as anchorages $2 \times 17 \times \cdot 668$ | 23 lbs. |
| γ. Wastage | 50 lbs. |
| | 560 lbs. |
| | or 5 cwt. |

(*b*) Binding wire, $\frac{1}{4}$ lb. per joint—

$\frac{1}{4} \times 54$ ... ... ... ... ... $13\frac{1}{2}$ lbs.

(*c*) Cement ... ... ... ... ... ... 16 cwt.

(*d*) Sand

| | |
|---|---|
| α. In mortar ... ... ... | 40 |
| β. Covering slabs ... ... ... | 15 |
| γ. Waste ... ... ... ... | 20 |
| | 75 cub. ft. |

(*e*) Bricks at 500 per 100 F.S., including wastage $\frac{364 \times 500}{100}$

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II. *Carriage.*

| | Rs. | a. | p. |
|---|---|---|---|
| (*a*) Cement and iron, 2 carts at 10 annas ... ... | 1 | 4 | 0 |
| (*b*) Bricks, 1820 at Rs.3 2a. per thousand ... ... | 5 | 11 | 0 |
| | Rs.6 | 15 | 0 |

III. *Labour.*

(*a*) Fixing centring—

| | Rs. | a. | p. |
|---|---|---|---|
| 5 Carpenters ... ... ... ... ... | 12 | 0 | 0 |
| 8 Coolies ... ... ... ... ... ... | 5 | 0 | 0 |
| ½ mate ... ... ... ... ... ... | 0 | 12 | 0 |
| | Rs.17 | 12 | 0 |

(*b*) Preparing iron, bending and wiring—

| | Rs. | a. | p. |
|---|---|---|---|
| 3 Blacksmiths ... ... ... ... ... | 4 | 12 | 0 |
| 4 Coolies ... ... ... ... ... ... | 2 | 8 | 0 |
| | Rs.7 | 4 | 0 |

(*c*) Soaking bricks in water, washing sand, laying bricks, covering with sand, watering, and finishing—

| | Rs. | a. | p. |
|---|---|---|---|
| 4 Masons ... ... ... ... ... ... | 9 | 2 | 0 |
| 16 Coolies ... ... ... ... ... ... | 9 | 12 | 0 |
| 3 Bhisties ... ... ... ... ... | 2 | 7 | 0 |
| ½ Mate ... ... ... ... ... ... | 0 | 12 | 0 |
| | Rs.22 | 1 | 0 |

*Note.*—It is considered that 2½ masons should lay the brickwork in one day on straight work. The above includes raising all materials to the roof level.

(*d*) Striking centring—

| | Rs. | a. | p. |
|---|---|---|---|
| 1 Carpenter ... ... ... ... ... | 2 | 8 | 0 |
| 4 Coolies ... ... ... ... ... ... | 2 | 8 | 0 |
| | Rs.5 | 0 | 0 |

Resumé of cost, excluding cost of material for centring.

I. *Materials*—

| | Rs. | a. | p. |
|---|---|---|---|
| (*a*) Iron, 5 cwt. at Rs.14 per cwt. ... ... ... | 70 | 0 | 0 |
| (*b*) Wire, 13½ lbs. at 4 ann. per lb. ... ... | 3 | 5 | 0 |
| (*c*) Cement, 16 cwt. at Rs.95 per ton ... ... | 76 | 0 | 0 |
| (*d*) Sand, 75 cub. ft. at Rs.7 per 100 cub. ft. ... | 5 | 4 | 0 |
| (*e*) Bricks, 1st class, 1820 at Rs.14 per 100 ... | 25 | 8 | 0 |
| | Rs.180 | 1 | 0 |

II. *Carriage* ... ... ... ... ... ... ... Rs.6 15 0

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| III. *Labour*— | Rs. | a. | p. |
|---|---|---|---|
| (*a*) Fixing centring ... ... ... ... ... | 17 | 12 | 0 |
| (*b*) Preparing rods ... ... ... ... ... | 7 | 4 | 0 |
| (*c*) Hanging roof ... ... ... ... ... | 22 | 1 | 0 |
| (*d*) Striking centring ... ... ... ... | 5 | 0 | 0 |
| | 52 | 1 | 0 |

| IV. *Centring, etc.*— | Rs. | a. | p. |
|---|---|---|---|
| (*a*) Share of carriage of materials for centring ... | 2 | 8 | 0 |
| (*b*) Share of cutting centring and making into panels | 5 | 0 | 0 |
| (*c*) Sundries, *viz.*, rope, nails, mortar pans ... ... | 2 | 8 | 0 |
| | Rs.10 | 0 | 0 |
| Total ... | Rs.249 | 1 | 0 |

Rate per square foot $\frac{\text{Rs.249 1ann.}}{364}$ = 10ann. 11p.

Say, eleven annas.

The cost of the cementing to the top side of the exposed roof is Rs. 0 1a. 6p. per sq. ft. in addition.

For comparison, the agreement rate for reinforced concrete for this work is Rs.4 per ft. cube, which is a fair rate for lintels or posts, but would probably have raised a contractor's claim for extra on a panelled roof. The rate for jack-arch roofing (excluding cost of steel joists) is Rs.46 9a. per hundred ft. cube. Both above rates include allowance for centring.

## PHOTOGRAPHS.

A. Shows reinforcement of verandah bressumer in position. The change at the point of contraflexure is clearly seen. The flat bars are not part of the reinforcement, but were ties to the tops of the verandah posts to resist the outward thrust of the sloping roof.

B and C. Show the laying of the verandah bressumer, for which calculations and drawings are given.

D. Shows rod in position wedged to right height.

E. Shows laying in progress. The roof was cantilevered out to the left to form a sunshade over upper windows. Hence the rods are bent up to the top of the slab. On the right can be seen the anchorage bar, round which the ends of the rods are hooked.

F. Shows the centring of the dining-room being struck. The lower side of the ceiling can be seen in the top right-hand corner and the tie-beam of the truss that carries it.

*Conclusion.*—The method of calculation and most of the hints on which the above paper is based were obtained from Capt. W. Hamilton, Garrison Engineer, M.W.S. Jhelum.

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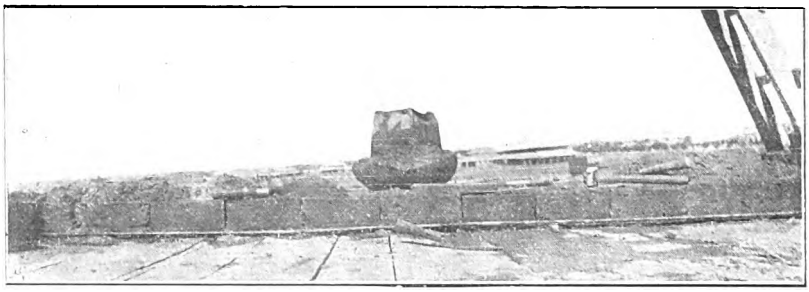
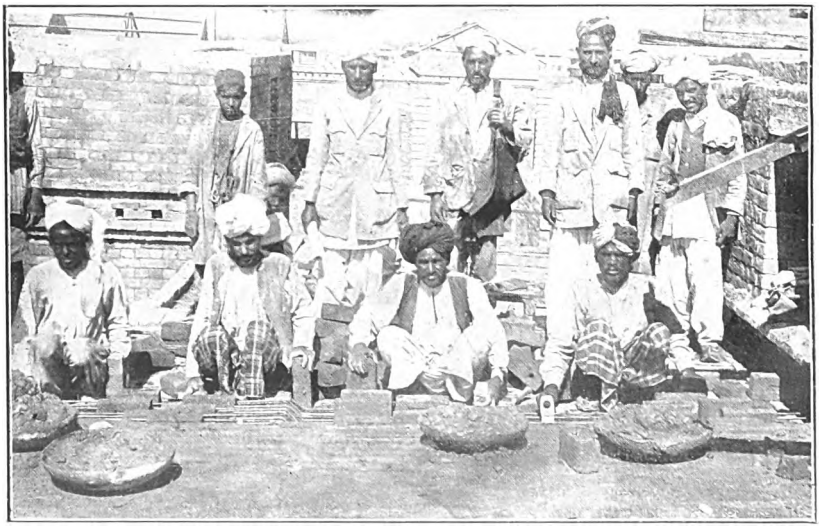
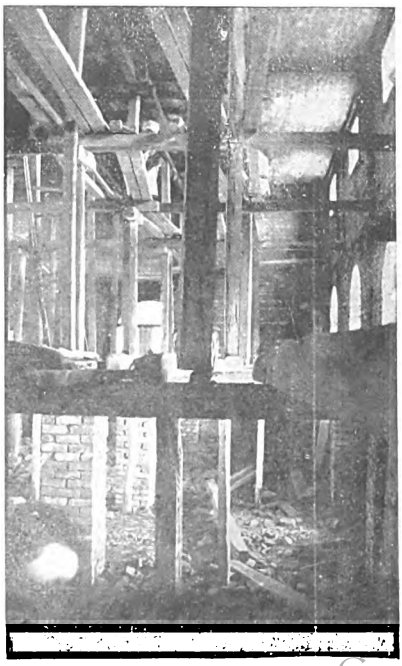
D.



E.



F.



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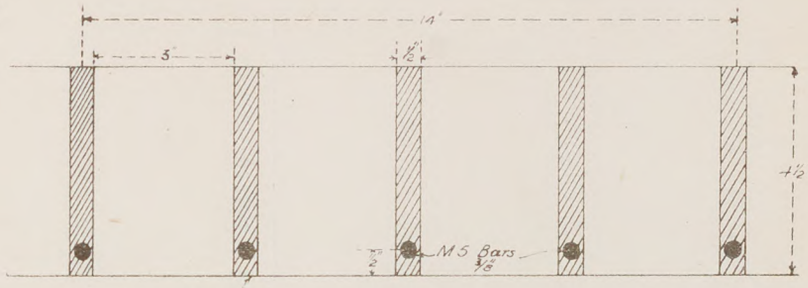
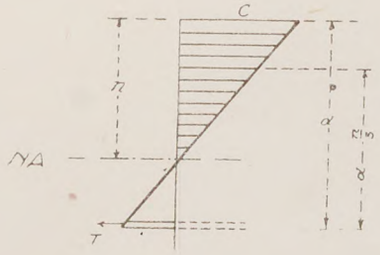
SKETCH I.



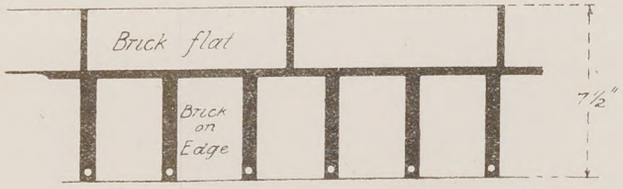

Section through Roof 4½ thick

SKETCH II.




Forces in Beam

SKETCH III.




7½" BRICK ROOF

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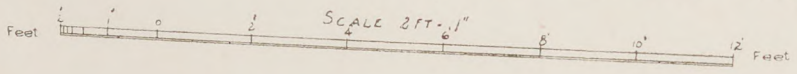
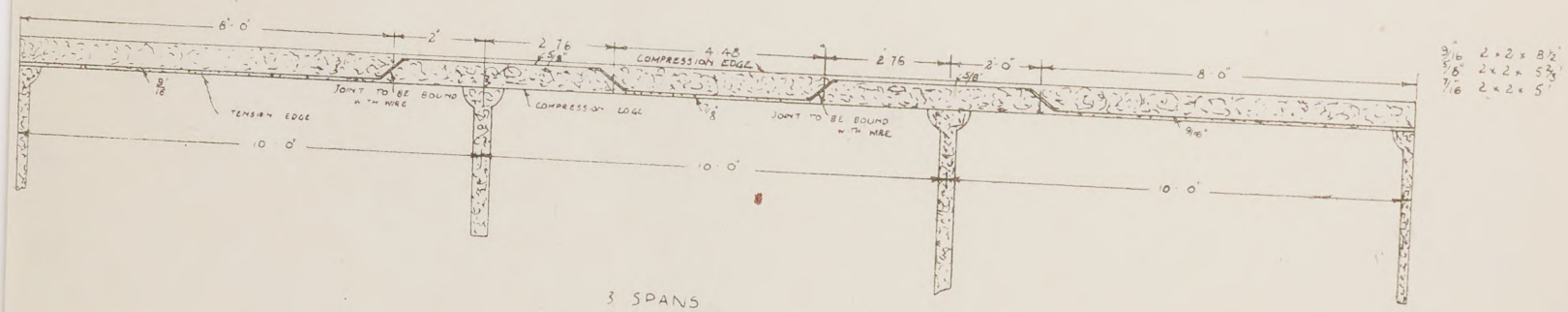
# DETAIL OF REINFORCED VERANDAH ROOF FOR OFFICERS HOSTEL, CHAKLALA.




3 SPANS

SKETCH IV.

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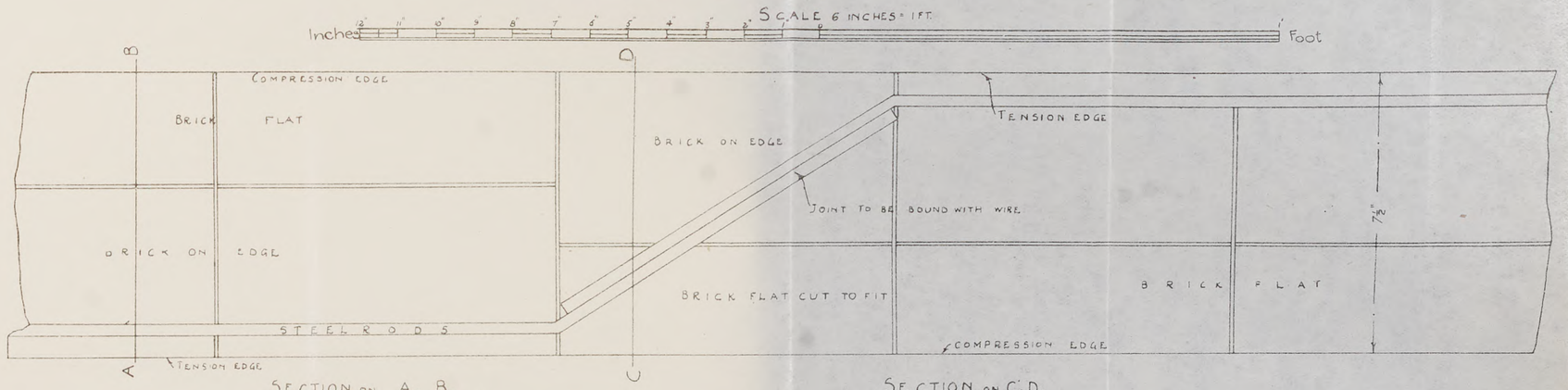
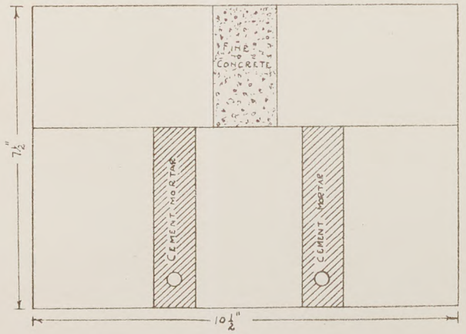
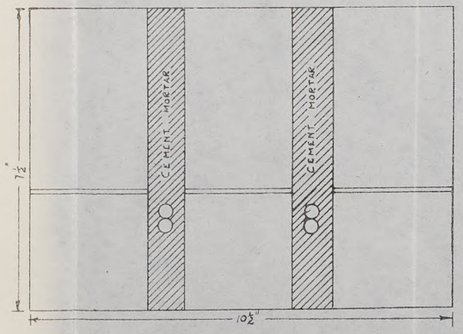
# ROUGH SKETCH SHOWING ARRANGEMENTS OF BRICKS AT POINTS OF CONTRAFLEXURE IN VERANDAH BRESSUMER OF OFFICERS HOSTEL.




SECTION ON A. B.




SECTION ON C. D.




(S. D) F. PREEDY
BT MAJOR RE
ASSTT COMMANDING ROYAL ENGINEER
M. W. S. CHAKLALA DISTT
DATED

CAPTAIN R. E.
GARRISON ENGINEER WORKSHOP
M. W. S. CHAKLALA
DATED

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BEHAVIOUR OF REINFORCED BRICK BEAMS UNDER TEST.

| Place. | Description. | Wt. of Beam. lbs. | Applied Load. lbs. | Total Dist. Load. lbs. | Deflection inches. | |
|---|---|---|---|---|---|---|
| Sialkot ... | Beam 12-ft. clear span, 14 in. wide, $4\frac{1}{2}$ in. deep, reinforced with five $\frac{3}{8}$ in. bars. Tested 65 days after construction. | 2775 | 756 | 3531 | ·05 | Figures supplied by Capt. Wm. Hamilton, M.W.S. |
| | | | 1512 | 4287 | ·12 | |
| | | | 2268 | 5043 | ·22 | |
| | | | 3024 | 5799 | ·33 | |
| | | | 3780 | 6555 | ·44 | |
| | | | 4536 | 7311 | ·61 | |
| | | | 5292 | 8067 | ·75 | |
| | | | 6048 | 8823 | ·89 | |
| Chaklala ... | Beams 10-ft. span, 14 in. wide, $4\frac{1}{2}$ in. deep, reinforced with three $\frac{5}{8}$ in. rods. Tested 14 days after erection. | | | | | $\phi$ Load was applied centrally, hence is multiplied by 2 to give figures in this column. |
| | (*a*) Cement 1 : 4 | 525 | 1170 | 1695 | $\frac{9}{16}$ in.* | |
| | | | 1800 | 2325 | $\frac{3}{4}$ in. | Beam failed. |
| | (*b*) Cement 1 : 3 | 525 | 462 | 987 | $\frac{1}{8}$ in. | |
| | | | 2100 | 2625 | — | Beam failed. |
| | (*c*) Cement 1 : 1 | 525 | 510 | 1035 | $\frac{1}{8}$ in. | |
| | | | 3510 | 4035 | $1\frac{1}{16}$ in. | |
| | | | 3646 | 4171 | $1\frac{3}{4}$ in. | |
| | | | 3856 | 4381 | — | Beam failed. |

* Deflection reduced to $\frac{1}{4}$ in. when load was removed.

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## *GERMAN RAILWAY WORKING*, 1921–22.

*By* BT. MAJOR (TEMP. LT. COL.) L. MANTON, D.S.O., O.B.E., R.E.

"How is Germany to pay?" is a question which is exercising many minds in Europe to-day. There are many theories, but no solution has yet been made known. The French have, pending a solution, seized pledges which are to be productive, and among these pledges are the Railways of the Rhine and Ruhr. The British do not believe in the productive pledge policy: the German does not believe in the French pledge policy, but offers instead a far bigger pledge—to wit, the whole German railway system. The offer has not met with much enthusiasm, but certainly merits critical examination.

Such examination must be made with one object in view—the financial result of acceptance. And with the word "finance" one strikes at once the main stumbling-block, which stultifies any ordinary investigation from the business point of view. The only absolute standard of measurement, money, has disappeared from Germany. The *Mark* since 1919 has descended in value in a hyperbolic manner and, having now practically reached infinity, it makes it impossible to draw up a balance sheet for any business, let alone a railway. But even if one turns to pre-war figures and a stable currency, the accounts of the German Railways are not drawn up in a form which provides a definite basis for judging the undertaking as a business.

It was not treated as a business. The German Railways were not even a state railway: the undertaking was a federation of state railways, each state owning its permanent way, rolling stock, etc., each having different conditions of service for its personnel and each keeping separate accounts. Each state had a capital value debited against its railway property, but, being state property, this value was only to a certain extent represented by actual outlay or loans or private property of any sort. One might just as well talk of the capital value of the Navy or of the Post Office. The Railways were in the majority of cases built from state funds, in accordance with a "Budget," actual construction forming as a rule the subject of an "extraordinary" Budget. The ordinary "Budget" deals with normal current income and expenditure, including in the latter a proportion of the state debt service and the cost of construction of items costing less than *M.* 100,000—(£5,000); and it is this "Budget" which forms the main accounts of the German Railways and which shows the net surplus, commonly regarded as the "profit" on

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working the railways. That it is no "profit" in the true sense is evident from the fact that it does not emerge from a profit and loss appropriation account following on a capital account balance sheet, but merely from a statement giving the difference between income and expenditure.

As illustrating the difference between the ordinary Budget and the "extraordinary" Budget, it is interesting to quote the 1921 *Budget* figures (not actuals). An income of *M.* 37,504 millions was estimated, against an *ordinary* Budget expenditure of *M.* 48,339 millions, i.e. a deficit of *M.* 10,835 millions to be made up from public funds. In addition to this drain, State funds were called upon to provide for the "extraordinary" Budget, a further *M.* 24,796 millions, of which there was to be spent on

Rolling Stock building, and fitting with Kuntz Knorr brake *M.*4,080 millions: and on
Construction generally, *M.* 2,114 million —

while the rest, *M.* 16,332 millions, was to pay an instalment to the individual states of the cost of acquisition by the German Empire of their railways.

These figures simply do not bear examination from a *business* point of view—they would be immoral. Whether they bear examination even from the point of view of State finance is doubtful, when one considers that the State in question is burdened with a Reparations debt. They are, however, sufficient to show that the accounts are not on a business footing, but, on the other hand, that the German Railway accounts differ in no important respect from the usual method of accounting for State funds.

On 1st April, 1920, the federation of State railways became *the* State Railway of Germany, and funds and accounts were centralized. Had conditions in Germany been "pre-war" in other respects, the accounts might have borne comparison with "pre-war" German accounts; but conditions are totally different.

How different must be briefly explained. In the first place, the railways were used as a reservoir to absorb demobilised soldiers, thus introducing (*a*) a surplus of personnel and (*b*) an unfair proportion of unskilled labour which hampered the efficiency of the skilled staff.

An actual comparison of numbers with pre-war is not possible from the figures available, but the German report gives the following figures as indicating relative efficiency. The German standard of "work done" is the wagon-axle-kilometre; and, while in 1913 a thousand wagon-axle-kilometres required 7·11 man-days, the same result was only attained in 1919 by 16·53, in 1920 by 14·46, and in 1921 by 12·78 man-days. Similarly, as an example of directly technical working, in 1914 the German locomotive consumed per mile 49·4 lbs.

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of coal: in 1919, 75·9 lbs.: in 1920, 69·9 lbs.: and in 1921, 63·75 lbs. The corresponding figure for Great Britain is 54·8 in 1921 and 54·64 in 1922. The normal "peace-time" figure to which one used to work was 50 lbs.

Again, the rigid application of the eight-hour day forced a permanent increase of staff, i.e. the surplus of personnel became surplus to a lesser degree.

Thus, while the total employees of the State Railways numbered in 1921 in April 1,064,966 and in December 1,048,442, an order was issued in January 1922 to reduce staff, and by May a reduction had been effected of 43,124, bringing the total down to 1,021, 842. This was felt so severely that staff had to be re-engaged, and in the following four months 20,417 persons were enrolled. Allowing for a loss of 10,000 in Upper Silesia, the figure for the end of September 1922 is given as 1,032,243 heads. The variation is quite unimportant and shows that the eight-hour day effectually prevented economy in this direction.

In the next place, the whole flow of pre-war traffic was altered in direction and intensity by the loss of the Saar coalfields, the loss of the industries of the basin of the Moselle in Lorraine, the loss of the Upper Silesian coalfields, the loss of the agricultural produce of Poland and the deflections concurrent with the creation of the "Polish Corridor."

The year 1921 introduced particular difficulties on the German Railways owing to the introduction by the Allies of a Customs barrier on the east of the occupied territory, which caused very heavy delays to goods traffic. More important still was the drought which so hampered water traffic on the Rhine and the Elbe that the railways in the Cologne district and the Hamburg district suffered from very severe congestion. These transitory effects, however, are not as important as the permanent ones mentioned above. The loss of the Saar coalfields forces South Germany to turn for its coal to the Ruhr and Upper Silesia. Berlin, Hamburg and many cities of the coast area, which used before the war to depend on English coal, turned on account of the war and the subsequent devaluation of the *Mark* to the Ruhr and to Upper Silesia, only to find that, owing to Reparations deliveries, they were unable to get the quality of coal required and had again to turn to England; but in the meantime there was caused a tremendous expansion of the brown coal industry. Thus the wagons placed for brown coal loading in Central Germany rose from 1,961,820 in 1913 to 2,423,060 in 1921; in Saxony from 433,338 to 620,928 and on the left bank of the Rhine in the Cologne area from 628,859 to 892,708, and this expansion is continuing.

Again, all kinds of trade conditions have arisen which may or may not have a permanent character, depending on the way in which

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the future currency of Germany works out in relation between internal and external purchasing power. In 1921 the feverish prosperity consequent on inflation had begun to take full effect and resulted in an enormous increase of the manufacturing trade in Saxony and in the Ruhr. This had its effect on the ports of Bremen and Hamburg and caused railway congestion at these two places and in Dresden and Leipzig. It also affected agricultural trade such as, for instance, that of the potato markets. In peace time the west of Germany drew its requirements from Holland and Belgium. In the autumn of 1921, being unable to buy abroad, potatoes had to be imported from the Stettin district and from further east, which effect went so far as to create a record potato traffic through Stettin.

The last factor to which attention must be drawn is the irregularity of traffic caused by the Rates policy of the German Railways. Every time an increase of rates and fares was announced a rush of traffic followed to take advantage of those existing prior to the increase.

Even without the effect of the war weariness of the people, and even assuming the existence of a stable currency, such changes must render useless any comparison of post-war results with those of 1913. And the existing monetary conditions set the seal of impossibility on any examination of the working of the German State Railways by the ordinary monetary standard.

What standard is to be adopted? It is admitted on all sides that the railway is a public utility *business*; and the aim of that business is to sell "transportation," an intangible something which so far lacks definition and lacks it to an extent which is not usually realised. There is still much difference of opinion as to the method by which the output of a railway is to be measured and costed. This difference of opinion is clearly reflected in that the Ministry of Transport has introduced quite new statistics in England since the war. The English statistics differ from the German in very many respects and radically in that the basis to which the English work as a *standard of measurement* is the ton-mile of goods and the passenger, while the German uses the axle-kilometre, both for coaching and goods traffic, on which to base costs. Since costing is clearly impossible in the case of the German railways, one can only choose a few items of output for purposes of comparison with other railways whose costs *are* measurable.

The choice of items is a matter of considerable difficulty. It is necessary to explain briefly what ideas have governed the choice and to do this one must come down to bed-rock principles.

A railway exists by virtue of the fact that a locomotive running on a smooth track can haul a very large load at a very small cost. The essentials of a railway are then the locomotive and the smooth road or permanent way. Land for this is acquired and the permanent

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way and its ancillary buildings are constructed at a certain cost, which remains the same whether the permanent way is used or not used. The cost of the maintenance of the permanent way remains practically constant whether much or little use is made of it. This railway having been built for the purpose of making the permanent way and the locomotives earn money, it follows that the object for which the management must strive is to obtain the maximum possible use of these two primary articles. In other words, the management strive to create sufficient traffic to justify the passing over of the track by the maximum number of engines. The locomotive is, however, by itself a spending factor, not the earning factor; it is the load behind it which earns money for the management, and it is therefore the management's further object to obtain for each locomotive the maximum paying load which it can haul. Apart from all the complications which the management have to face, and which must be borne in mind when criticizing, it is not unfair to take as a measurement of output the amount of paying load which the management succeed in making their engines haul over the whole of their permanent way; and for the purposes of comparison, since the length of the railway systems differ, all such figures of output have been reduced to the unit "Per route mile," route miles being the length of the railway system quite apart from the number of tracks which may be laid over that length. In 1921, the British railways worked 20,281½ miles of route, on which 51,477½ miles of permanent way had been laid. The German railways in the same year worked 33,155 miles of route, on which 73,626 miles of track had been laid. The figures of *route* mileage (the lesser) are those which have been used in producing the calculated results which follow. The first comparison will be of the use made of these route miles by the engine.

An engine is doing what it was invented for when it is putting miles of route behind it. This leads to the "engine mile" as the unit by which the use of locomotives is measured and for statistical purposes engine miles are divided into four categories, viz. "Coaching train miles," when hauling passenger trains; "freight train miles" when hauling goods trains; "shunting miles" for work performed in a station or goods yard and "other miles" for other work, covering the time engines are in use for purposes not included under the first three heads. Of these heads the first two directly earn money: the other two do not, and they therefore represent a "complication," not an output. The comparable figures are:

| | *English* | *German* |
|---|---|---|
| Coaching train miles per route mile | 10,128 | 5,250 |
| Freight train miles per route mile | 5,410 | 4,260 |
| Total | 15,538 | 9,510 |

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showing that the English railways attain a traffic nearly twice as *intense* as the German. But these train miles do not represent earnings.

" Earnings " bring in an entirely different factor, to wit, the success with which the management can persuade the public to make use of their output, or, to put it another way, good management strives not to produce more output than the public will use *fully*. The coaching train mile output is produced for the benefit of passengers and the number of passenger journeys made in 1921 was in Great Britain 1,786,671,112 and in Germany 2,318,499,589.

These figures do not go far enough as an indication of the potential earning capacity of the passenger traffic. To obtain this it is necessary to introduce the distance factor, since the further the average passenger goes, the more he pays. The average English passenger travelled 10·77 miles, while the average German passenger travelled 13·26 miles, and one is thus able to state that the relative potential earning capacity of the two systems was

| | *Number of passengers* × *average distance* |
|---|---|
| *Great Britain* | 1,786,671,112 × 10·77 = 19,242,447,876 passenger miles |
| *Germany* | 2,318,499,589 × 13·26 = 30,743,304,550 passenger miles |

or, when applied to the route miles standard,

| | |
|---|---|
| *Great Britain* | 948,792 passenger miles per route mile, |
| *Germany* | 957,711 passenger miles per route mile, |

showing that the British and German public travelled practically to the same extent: but the German public was carried at half the expenditure of output (coaching train miles per route mile) of the British. It is unfortunately not possible to say how far the British public made use of (or were forced to make use of) the available *seats* moved, since the British statistics give no indication of " seat miles " which would be the true measure of output. But the German statistics state that on the year's average 39·15% of the available seats were occupied in their passenger trains.

The passenger train is, however, not usually as great a source of revenue as the goods train, the engine of which earns money by hauling a load of wagons, which contain goods whose quantity is measured in tons. The same standard of judgment applies to goods traffic as to passenger traffic, i.e. the management strives to persuade the public to use 100 per cent of its output. The nearer the load carried in the wagon approaches to the limit of the wagon's carrying

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capacity and the nearer the load behind the engine approaches to its maximum hauling capacity, the better from the earning (and consequently from the management's) point of view. The comparative results (all based on 1921 figures) are as follows:

| | *Great Britain* | *Germany* |
|---|---|---|
| Freight train miles per route mile | 5410 | 4260 |

That part of the train load which *pays* is the goods in the wagon, and the use made of the system by tons of goods is shown by

Tons carried in 1921 *Great Britain* 230,785,884 tons,
*Germany* 371,357,433 tons.

The German then carried more tons with fewer trains than the British companies. They managed to do this because the nature of the traffic they deal with admitted of an average train load (paying load) of 249·4 tons against an average English train load of 121·17 tons—i.e. a train load twice as great as the English. (In parenthesis, it may be stated that the *American* corresponding load was 647 tons in 1920.)

The amount of effort required to do this, i.e. the amount of wagon capacity used is shown by the average carrying capacity of the available wagons, which was

*Great Britain* 10·221 tons
*Germany* 15·37 ,,

and the average amount loaded into each wagon, which was

*Great Britain* 5·07 tons of paying load
*Germany* 11·2 ,, ,, ,, ,,

from which one deduces that the average German freight train carried paying freight up to 72 per cent of wagon capacity, while the English freight train only reached 49 per cent. The German percentage is extraordinarily high.

While tons carried indicate the amount of the load which pays, they do not indicate the amount of revenue coming in to the railway company until it is shown *how far* they have been carried. In general, the further goods travel the more revenue do they produce. Consequently one requires to multiply the amount carried by the distance it was carried before one arrives at a figure giving an indication of the potential revenue which can be extracted from Goods Traffic. The average distance traversed by the goods carried was in England 57·58 miles, and in Germany 95·05 miles. Multiplying "amount" by "distance" gives the *Ton Mile*—probably the most

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useful unit of goods traffic measurement yet devised: and the corresponding figures are for 1921

| | |
|---|---|
| *Great Britain* | 13,288,985,777 ton miles |
| *Germany* | 34,827,735,401 ton miles ($\frac{5}{8}$ of 55,724,376,642 ton-km.) |

or per route mile

| | |
|---|---|
| *Great Britain* | 661,769 ton miles per route mile |
| *Germany* | 1,052,162 ,, ,, ,, |

showing a potential earning power in German goods traffic 60 per cent. higher than that of Great Britain. And it is with potential earning power that this paper set out to deal.

It has been sufficiently dealt with to enable certain conclusions to be drawn. But before even general conclusions are drawn a note of warning must be sounded on the subject of the statistics from which the figures have been compiled. They are the official statistics as published by the respective Ministries of Transport and must be taken as perfectly honest: but all statistics, and especially railway statistics, have to be regarded with understanding and sympathy. They are drawn up much more for the purpose of enabling an authority to compare results with previous periods than for actual purposes of measurement, so that an inaccurate basis will give relative results bearing a definite and useful relation to each other, period by period, while presenting a perfectly false picture to the uninitiated student of actual performance. It is only necessary to refer for an example to the method of obtaining freight ton miles. The British book states that the figure is obtained by multiplying the actual loaded wagon miles by the average load per wagon: and that the average load per wagon has been obtained by dividing the total tonnage handled by the total number of loaded wagons handled.

The German method is quite different and depends on the *revenue* obtained from each class of goods. It is very complicated and not worth explaining fully, and it very probably gives results nearly as accurate as the British: but the mere divergence of method is sufficient to show that any attempt to be dogmatic would be wrong.

Dogmatic statements would be wrong for another reason quite apart from statistics. Reference has already been made to the drought, to the currency question, and to the political events in Germany as effecting traffic in 1921, and it is only fair to draw attention to one outstanding event in Great Britain which also affected railway traffic, namely the coal-miners' strike in 1921. But even allowing for abnormal conditions on both sides, there seems to be a sufficiently wide difference between the potential earning capacity of the railway systems of the two countries to make it safe to say that the acceptance by the Allies of the German Railway System ought to be a handsomely paying proposition and that it would repay the labour

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involved to subject the German figures to criticism in order to ascertain, if possible, whether there is any very definite reason why the German Railways should have actually budgeted for a loss on working.

A criticism of German Railway Working based purely on statistics would be like dissecting Dead Sea fruit. It is essential, if any conclusions are to be drawn, to throw the light of observation and experience on to statistics and to judge them accordingly.

I have been fortunate enough to have had intimate dealings, from the administrative standpoint, with German Railways for some twenty-two months. During that time, I have been able to gather very definite impressions which the statistics do not in all cases bear out, but which, when applied to statistics, are a sufficient explanation of otherwise paradoxical results.

For the results shown are paradoxical. The German railways have carried more goods more miles in fewer trains and more passengers more miles in fewer trains than the English railways and yet the English railways incurred a gross loss of four per cent., while the German actually expected a loss of twenty-two per cent. on the ordinary Budget working. For the sake of clearness it must be repeated that the output or, in other words, the "transportation" which was offered for sale in 1924 amounted to

| | *British* | *German* |
|---|---|---|
| Coaching train miles | 205,415,970 | 173,983,803 |
| Freight ,, ,, | 109,708,783 | 141,142,872 |

This output, which the Germans call "Betrieb," represents the total *potential* earning power of the effort put forth by the Railway Administration. The output or "transportation" actually sold, which the Germans call "Verkehr," is shown by

| | *Great Britain* | *Germany* |
|---|---|---|
| Passenger journey miles | 19,242,447,876 | 30,743,304,550 |
| Goods ton-miles | 13,288,985,777 | 34,827,736,151 |

and it has been shown that the German sold 72 per cent of the goods train output, and 39 per cent of the passenger train output, while the British sold only 49 per cent of the goods output, that of the passenger train not being stated. In other words, the German management succeeded in keeping the amount of output down nearer to the "sales" level than the English and therefore, since they made a serious loss on working, their output must have been much too expensive, either absolutely or relative to income or both. The first thing to be examined then is the output.

"Output" is synonymous with visible expenditure. It was stated at the beginning of this paper that certain expenditure is incurred by a railway which has practically no relation to output—

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*e.g.* maintenance, general management, guaranteed interest on certain capital, etc. Consequently it is the cost of output which directly affects the gross profit or loss on railway working, and of this cost the majority is caused by two great bills—Wages and Material, the latter including coal and oil. Wages must in this case be translated into terms of " heads employed " since the ordinary monetary standard is lacking—and in this case comparison of statistics gives the following results :—

| | *Great Britain* | *Germany* |
|---|---|---|
| Total employees (1921) | 735,870 | 1,064,966 |
| Employees per route-mile | 36·5 | 32·1 |

Bearing in mind the fact that the rate of wages in Germany in no case reached the level of the " cost of living " figure during 1922, (and probably did not during 1921), while salaries were little better, it is hardly conceivable that the figures can be telling the truth as a measure of relative expenditure, and they must be looked at in the light of experience to find some reasonable explanation.

It is obvious that the German passenger train carries more personnel than the British ; the German express, for instance, carries driver and fireman ; brakesman, luggage guard (Packmeister), often with an assistant; guard (Zugführer) ; conductor (Schaffner), one or more ; and often attendants in the carriages themselves, (Wartefrau, etc. ). A goods train has never less than one brakesman in addition to driver, fireman and guard, and the number rises to eight and ten on the heavier trains or heavier sections of line where gradients necessitate more brake power. (It is to save these brakesmen that the Germans are fitting all their goods stock with the Kuntz Knorr brake, at which as a general administrative measure one can level a good deal of criticism.) The German station has more personnel than an English station. These things are there to be seen. A possible explanation of the coincidence which makes the British and German total figure of employees per route mile so alike is that Great Britain, more closely populated than Germany, has more stations per route mile, and that what is saved (relatively) on the smaller staff per station is made up by the greater number of stations per route mile. Unfortunately the British statistics are not so detailed as the German, so that one can only conclude that the British figures include items which do not appear in the German, or that the British do more work not *immediately* connected with operating. This conclusion is correct, for instance, in the case of locomotives. The Germans do not build new engines, but they buy them from private works; the British lines build their own locomotives to a large extent, and consequently employ more hands. Whatever the explanation, the fact remains that the paying British railways can employ more men per route mile at high wages than the losing German railway can

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employ at slave-driving rates. There are other comparative statistics which bear out the over-employment which one sees in Germany. The statistics of the Swiss *Federal* Railways are compiled on lines very closely copying the German model, and these give the following results :—

| | | *German* | *Swiss* |
|---|---|---|---|
| *Administration* | heads | 42,804 | 865 |
| | heads per route km. | *0·80* | *0·30* |
| *Permanent way and Maintenance* | heads | 195,563 | 8,385 |
| | heads p.r.k. | *3·66* | *2·91* |
| *Traffic* | heads | 418,274 | 17,717 |
| | heads p.r.k. | *8·40* | *6·15* |
| *Loco. and workshop* | heads | 364,257 | 5,731 |
| | heads p.r.k. | *6·82* | *1·99* |
| *Auxiliary services* | heads | — | 5,673 |
| | heads p.r.k. | — | *1·97* |
| *Total* | heads | 1,050,898 | 38,371 |
| | heads p.r.k. | *19·68* | *13·32* |

These figures are striking—so striking, indeed, in the case of " Locomotive and Workshop personnel," that it must be mentioned that the Swiss do not do locomotive repairs in their own workshops, but let this work out to tender, while the Germans repair most of their own locomotives and thus employ more hands in the shops. The Swiss statistics do not specify clearly the particular " auxiliary services " which employ the hands given under that heading, but one can add them to the locomotive and workshop figure and the result is still very damaging to the German results. Again, whatever the explanation, these figures, added to what he who runs may read, justify the conclusion that the German railways were over-staffed in 1921, a conclusion which the German Government has now (November, 1923) recognised afresh by ordering a 25 per cent. reduction. It remains to be seen whether this order will be more successful than the order of January 1922 already referred to. But in addition to superabundant staff, is there no other way in which the German output suffers from non-productive operative costs ?

Of all non-productive work on a railway probably that of the shunting engine is the greatest. It is unavoidable work, but it produces *no* ton-miles and *no* passenger miles, while it costs coal, oil and wages, and as a corollary it entails the cost of providing and maintaining shunting yards. The comparable figures are

| | *Great Britain* | *Germany* |
|---|---|---|
| Shunting engine miles | 102,739,026 | 204,055,631 |
| Per cent of total engine miles | 22% | 35·7% |
| Tons of wagon capacity per shunting engine *hour** | 24·1 | 15·8 |

* The Germans allow 10 km. and the British 5 miles per hour.

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and show a very serious difference. Not only do the Germans spend proportionately much more time on shunting than the British, but they actually turn out less per shunting engine. The result would be even worse, were one to translate it into *wagons* per hour, since the average capacity of the German wagon is 15·37 against the British 10·221—in wagons the proportion is 2·3 to 1 in favour of the British. These shunting figures lead one to suppose that the corollary mentioned above should hold good—*i.e.* that the Germans require more room for shunting than the British, and the track mileage of the two systems confirms this expectation. The British "siding" miles amount to 28·6 per cent. of the total; the German "siding" miles to 35·25 per cent. of the total track mileage, and this in spite of the fact that the British have relatively more stations.

These figures again bear out one's personal impression that the German shunting yards are altogether too big and unwieldy. They appear to have been laid out for the purpose of handling the greatest traffic which intelligent anticipation could foresee. The result of this is that they are too big for the ordinary everyday traffic using the yards. They are almost universally provided with a hump for shunting purposes, very often with several humps. They are well signalled and well provided with engine run-rounds: (in one case, at Gremberg, near Cologne, a double engine line is provided and carried under the neck of the marshalling yard, providing a flying junction), and they show deliberate design in every way, unlike the British yards which in most cases show clearly that they have grown with the traffic.

These impressions of the German Goods Yards apply equally to their arrangements for passenger traffic, which are most elaborate, and, as a general summary of impressions, the deliberate statement can be made that the Germans appear unwilling to, or incapable of, working with any general lay-out which falls short of the theoretically perfect. This mental attitude was capable of some defence when the German railways were working to a profit, unburdened with any kind of debt, in no doubt as to the source or quantity of future capital requirements, and untroubled by any thought of interest on such capital. It so permeates public opinion as well as the Railway Administration that it constitutes in my opinion one of the greatest factors which prevent the business-like handling of the German railways.

The German railways are unquestionably a very fine machine. The perfection of the design of this machine, deteriorated as it may be by ten years' mishandling, is obvious to the eye, and is proved by the fact that the output is maintained with half the effort required from the English railways. The fact that the output costs the Germans too much is amply proved by the figures for personnel as compared with the Swiss, by their own statement that a unit of work now requires twice as many man-days as it did before the war, and by the fact that

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their shunting expenditure is too great and its output altogether too low. But none of these factors were in any way hidden. The Germans were as well aware of them as any one else. There is unfortunately no way of proving whether the shunting figures are worse now than before the war—though the probability is strong that they were just as bad—but even allowing for that, there is no justification in any of these working figures for the grave financial loss incurred by the German railways in 1921 and in 1922. There can only be one explanation, and it lies on that side of the accounts which shows the income paid by the " transportation sold." This was quite insufficient, and draws attention to the extraordinary rates policy of the German administration. German railway rates have deliberately been kept at an unremunerative figure.

But to discuss rates fully would require a volume to itself. It must suffice for the purpose of this paper to quote their own report, and from it to let the German policy be judged. After referring to the increase of working costs, the German report says :—" It was believed that National German Interior Economy could not bear a load of expenditure on the transport of passengers and goods such as would correspond to the universal increase in cost. The railway, as one of the most important factors of economic life, was to try and combat the continued diminution in the value of money by consciously holding back from any increase in its prices. This policy which was carried on to the end of the first half of the year under report (1921) had in general the support of the Government of the Reich and the law-giving bodies, and was, at least at that time, hardly disputed at all." The report then goes on to say that the continued depreciation of the *Mark* made it necessary to raise rates in a measure at least to cover what the Administration call " Self-costs." How these " Self-costs " are arrived at as a current measure is not very clear, since the unit is the cost per axle-kilometre—obtained apparently by dividing Traffic receipts by axle-kilometres; and in view of the way in which the German accounts are kept, they would not appear to be very reliable, but for the purposes of the German report they are very useful since they enable a graph to be drawn showing the income keeping pace with the " Self-costs." As a measure of financial stability these graphs would seem to be valuable to a less extent even than the accounts of the railways.

The German railways are supposed to be self-supporting, and, indeed, Article 92 of the German Constitution says they must be. They have failed completely to be self-supporting, and they put their failure down to the depreciation of the currency. Certainly, the depreciation of the currency in 1923 must necessarily completely swamp any loss which may have been incurred for any ordinary reason, but this excuse must not be allowed to hide the fact that the German railways, provided that they had a really business-like

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rates policy, ought to make a handsome profit. Their rates at present bear no relation whatever to the cost of living, and once more the Germans must be judged from their own publications.

In a pamphlet entitled "Tariff policy of the German State Railway," (a pamphlet defending the raising of the rates !), there are little diagrams showing that, whereas before the war the price of ten eggs would take a passenger 45 kms., on the 1st February, 1923, they would take him 337 km; one pound of butter likewise would take him 62 kms. in 1913, and 600 kms. in 1923. Berlin to Frankfort-on-Main for the price of a pound of butter ! The index figure for the average wholesale prices in January, 1923, was 2,800, that of the average goods rate 1,650. One could go on repeating these figures almost indefinitely, but they do very little to assist one towards making an estimate of the probable profit or loss on working the German railways if the currency suddenly became stable, and rates reasonable. Sufficient has, however, been written to enable the nettle to be grasped and an estimate made.

Before actually estimating in figures, it is as well to draw up a summary of the conclusions come to. These can be put in the form of :—

| Points favourable to the German Railways. | Points unfavourable |
|---|---|
| 1. Low train mileage. | 1. Over staffing. |
| 2. Good utilisation of trains. | 2. Over shunting, with yards too big and output too small. |
| 3. A very fine machine. | 3. An unsound rates policy. |

In my opinion the favourable points heavily outweigh the unfavourable, except in the case of the rates. The Germans have now applied a rates policy on a gold basis, and one may assume for the sake of argument that the policy is now reasonable. One may further assume that, had the currency question never arisen, the changes in traffic direction and the other war effects to which reference has been made would not have done much more to affect the finances of the German railways than the social post-war changes have affected the finances of other railways. It is instructive to compare in this respect the effects of the war on the British and Swiss railways.

The *Gross Expenditure* was :—

| | *Gr. Britain* | *Proportion* | *Swiss Fed. Rys.* | *Proportion* |
|---|---|---|---|---|
| 1913 | £75,704,320 | 1 | frs. 142,406,000 | 1 |
| 1920 | £231,968,870 | 3·25 | frs. 358,328,000 | 2·5 |
| 1921 | £226,767,460 | 3·0 | frs. 341,918,000 | 2·4 |
| 1922 | £174,844,342 | 2·3 | — | — |

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The *Gross Receipts* were :—

| | *Gt. Britain* | *Proportion* | *Swiss Fed. Rys.* | *Proportion* |
|---|---|---|---|---|
| 1913 | £119,808,270 | 1 | frs. 212,721,000 | 1 |
| 1920 | £238,930,239 | 1·99 | frs. 394,031,000 | 1·85 |
| 1921 | £217,796,991 | 1·81 | frs. 353,972,000 | 1·66 |
| 1922 | £210,330,693 | 1·83 | — | — |

Considering how utterly the economic conditions in the two countries differ, it cannot be taken as a mere coincidence that the proportionate rise in expenses and the rise in revenue are so nearly alike in 1920 and 1921. The similarity in the case of traffic receipts and expenditure per route kilometre/mile respectively is even more striking.

*Traffic Receipts per mile or km.*

| | *Gt. Britain* | *Proportion* | *Swiss Fed. Rys.* | *Proportion* |
|---|---|---|---|---|
| 1913 | £ 5,868 | 1 | frs. 76,491 | 1 |
| 1920 | £11,649 | 1·98 | frs. 136,721 | 1·78 |
| 1921 | £10,621 | 1·82 | frs. 122,822 | 1·605 |
| 1922 | £10,709 | 1·83 | — | — |

*Traffic Expenditure per mile or km.*

| | *Gt. Britain* | *Proportion* | *Swiss Fed. Rys.* | *Proportion* |
|---|---|---|---|---|
| 1913 | £ 3,720* | 1 | frs. 51,207 | 1 |
| 1920 | £11,430* | 3·075 | frs. 124,333 | 2·43 |
| 1921 | £11,142 | 2·99 | frs. 118,639 | 2·31 |
| 1922 | £ 8,592 | 2·3 | — | — |

These figures are good evidence, even if they do not prove, that the rise in expenses, or, put the reverse way, the depreciation in the purchasing power of money is comparatively universal in Europe, and relatively uniform when measured in stable currency.

It is not unfair therefore to apply the proportion to Germany and to base on the result an estimate of the gold currency result of Railway operation in that country.

Unfortunately the only statistics immediately available to me for the *whole* of the old Germany are those of 1901, and it is necessary to relate these to the 1913 statistics of the Prussian-Hessian Railways in order to arrive at comparable figures. The receipts per kilometre in 1901 were :—

| | | |
|---|---|---|
| For all Germany | *M.* 39,418..... | 90·88% |
| For Prussia-Hessen | *M.* 43,463..... | 100% |

In 1913 they were :—

| | | |
|---|---|---|
| For Prussia-Hessen | *M.* 65,106 ..... | 100% |

* Estimated on *Gross* Expenditure and consequently slightly high.

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and consequently, taking the same proportion for 1913 as 1901, we may assume that they were :—

For all Germany *M.*59,168 ..... 90·88%

Now, it will be observed that British receipts rose from 1 to 1·83 in 1922, and the Swiss from 1 to 1.605. It will be no injustice then to apply the lower multiplicator to the German figure thus :—

59,168 × 1·6 = *M.*94,669 per route kilometre.

In 1921 the route kilometrage was 53,357, which gives a gross receipt for Germany of :—

*M.*5,051,253,833

Turning to the expenditure side we find that the expenditure per kilometre in 1901 was :—

For all Germany *M.*25,913 ..... 97·33%
For Prussia-Hessen *M.*26,622 ..... 100%

in 1913 :—

For Prussia-Hessen *M.*45,058..... 100%

and consequently, taking the 1901 proportion for 1913, we may again assume that expenditure per kilometre was in 1913 :—

For all Germany *M.*43,855 ..... 97·33%

In 1921 the Swiss expenditure was 2·31 times that of 1913 ; in 1922, the first uncontrolled year, and the first year which did not include some national calamity such as the coal strike, the British railways arrived at practically the same " multiplicator." Applying it, then, to the all-Germany expenditure figure, this gives :—

43,855 × 2·3 × 53,357 = a gross expenditure of

*M.*5,381,933,840

showing a loss of

*M.*330,680,007.

Applying the same multiplicators to Gross Receipts and Gross Revenue, adjusted to mileage differences between 1913 and 1923, this gives :—

| | |
|---|---|
| Revenue | *M.*4,961,964,335 |
| Expenditure | *M.*5,322,060,872 |
| Loss | *M.*360,096,537 |

from which one arrives at the important deduction that if receipts increase by 1·6 times only, the greatest expenditure which the revenue will stand is attained with an increase over pre-war by 2·16 or 2·14 times; or, in other words, the German Railway Wages bill, Coal bill and all other bills for current expenditure when reduced to a mileage

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basis must not exceed the pre-war dollar value by more than 2·14 times, while the increase in income per kilometre at dollar values must average out at something over 160 per cent. of pre-war rates This conclusion, even if negative, is of some value and is justified in two ways. The multiplicators used are those of the Swiss Federal Railways in 1921, and it is firstly interesting to note that in that year the Swiss railways only just managed to make receipts exceed expenditure. In 1913 the difference between receipts and expenditure of the Swiss Federal Railways was frs. 70 million, in 1921 it was only frs. 12 million. The Swiss demonstrably do not suffer from the overstaffing disability, which alone is sufficient to turn a narrow "plus". on the Swiss Federal Railways into a "minus" on the German railways, and, as a second justification, it is sufficient comment on the German rates policy when it is stated that the *actual* income on a dollar basis from goods traffic shows a multiplicator ranging from ·907 in June, 1922, to ·2435 in November, 1922.

And with that plea of justification this paper must be brought to an end.

The writing of it has proved one thing to me—that dogmatism on any subject connected with railway working is quite impossible in the present state of our knowledge. Such conclusions as have been come to are put forward with all diffidence and considerable hesitancy, while the last conclusion, the estimate of the possible financial result of working the German railways with reasonable rates and an unastronomical currency, requests the charity of being called an intelligent guess.

The statistics used are summarised in the attached *Appendix*.

NOTE :—Since the above was written in November, 1923, conditions have changed in the following respects :—

1. The "Miracle of the Rentenmark" has restored a currency which is being held to a dollar value.

2. A real effort appears to be in hand to make the German State Railway independent of the Treasury and thus really self-supporting. The Treasury will of course take any profit made by the railway but will not grant credits.

3. Goods and Passenger rates are decidly on the high side, measured in Rentenmark.

4. Reduction of Staff, lengthening of the hours of work and reduction of pay are being carried out.

It is too early to judge of the permanency or of the effects of these changes.

10*th February*, 1924.

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# GERMAN RAILWAY WORKING, 1921-22.

| REF | # HEADING | GREAT BRITAIN. | GERMANY. | SWITZERLAND. |
|---|---|---|---|---|
| A 1 | Route Miles (all Gauges) | 20 281 5 | 58357 km { 51365 km Pass / 52961 km Goods } 33.156 miles | 2882 km 1800 miles |
| A 2 | Track Miles (Running) | 36,781 5 or 7.14/- Total | 74708 km 47 664 miles or 64.75% of Total | 3983.6 km 2471 miles or 71.5% of Total |
| A 3 | (Sidings) | 14 726.0 or 28 6/ of Total | 41.780 km 25 962 miles or 35.25/ of Total | 1568.8 km 980 miles or 28 5% of Total |
| A 4 | Total | 51 477.0 or 2 55 miles per Route mile | 119 485 km 73 626 miles or 2 22miles per Route Mile | 5522 3451 miles or 1 92 miles per Route Mile |
| B 5 | Engine Train Miles (Coaching) | 205 415 970 } 315 124 753 | Schnell 38 438 970 / Ell. 6 868 730 / Personen 232 055 423 / Milit 1 015 982 } 278 374 085 km 173 983 803 miles | 7 930 000 Km } 24 394 000 km. 11 206 996 miles } 15246 328 miles |
| B 6 | Engine Train Miles (Freight) | 109 708 783 } | Eilgut 19 124 074 / Gut 203 078 008 / Arbeit 3 626 515 } 225 828 595 km 141 142 872 miles } 315 126 675 miles | 8 464. 000 km 4 039 332 miles |
| B 7 | Engine Shunting Miles { Coaching / Freight } | 15 708 909 / 87 030 117 } 102 739 026 | 326 489 010 km 204 055 631 miles | 4 626 858 Km 2 891 786 miles |
| B 8 | Other Engine Miles | 48 370 266 | 84 830 478 km 53 019 050 miles | 582 772 Km 364 232 miles |
| B 9 | Total Engine Miles | 466 234 045 | 572 201 356 miles | 29 603 754 18 502 346 miles |
| C 10 | Engine Miles per Route Mile | 23.000 | 17 260 miles | 10272 |
| C 11 | Coaching Train Miles per Route Mile | 10 128 } 15 538 | 5 250 } 9 510 miles | 6221 } 8465 |
| C 12 | Freight Train Miles per Route Mile | 5 410 } | 4 260 } | 2244 } |
| D 13 | Total Passengers Journeys No | 1 786 671 112 | No 2 318 499 589 | No 80 681 000 |
| D 14 | Average Length of Journey Miles | 10.77 | 21 22 km 13 26 miles | 22 8 KM 14 25 miles |
| D 15 | Total Journey Miles | 19 242 447 876 | 49 192 319 428 km 30 743 304 550 | 1 130 000 000 |
| D 16 | Journey Miles per Route Mile | 948 792 | 957 711 | 639 000 |
| E 17 | Freight capacity Hauled | wagon miles x av wagon cap 3 780 298 852 x 10 221 tons } 38 638 434 566 | axle miles x av cap per axle 10438 488 430 x 7 53 } 78 610 347 877 | axle miles x av cap per axle 207 111 184 x 6 7 tons } 1 387 644 932 |
| E 18 | Freight capacity hauled per Route Mile | 1 905 159 tons | 2377 553 tons | 770 913 tons |
| E 19 | Total Ton Mileage | 13 288 985 777 | 55 724 376 642 | 849 477 425 T km 593 423 391 T m |
| E 20 | Ton Mileage per Route Mile | 661 769 | 1 052 162 | 329 500 |
| F 21 | Relation of Tonnage hauled to Capacity hauled | 34 7/. | 44 3/ | 42 7/ |
| G 22 | Average length of Haul (Freight) | 57 58 miles | 152 08 Km 95 05 miles | 78 3 Km 49 3 miles |
| G 23 | Average Freight Train Load | 121 17 tons = 49% of Capacity | 249 4 tons = 72% of Capacity | 525 axles x 2 2 tons 115 5 Tons = 32 75/ |
| G 24 | Average Capacity per Wagon | 10 221 tons | 15 37 tons | 6 7 tons per axle x 2 13 4 tons |
| G 25 | Average Load per Wagon | 5 07 tons | 11 2 tons | 2 2 x 2 4 4 tons |
| H 26 | Coal consumed per Engine Mile | Pre war about 50 lbs | 1914 49 4 lbs | |
| | | 1919 | 1919 75.9 | |
| | | 1920 | 1920 69 9 | |
| | | 1921 54 8lbs | 1921 63 75 | |
| | | 1922 54 04 | 1922 | |
| J 27 | Total Staff & No per Route Mile | 3/1921 735 870 - 36 5 | 4/1921 1.064.966 - 32 1 | 13 32 per Route Km. 1921 38 371 - 21 31 |
| | | 3/1922 676 802 - 33.5 | 9/1922 1.032.243 - 31 2 | |
| | Staff by Departments | | av 19.68 per km or 31 66 mile | |
| J 28 | Administration Verwaltungsdienst | | 0 86 per Km 42 804 - 1.29 | 0 30 per Km 865 - 0 48 |
| J 29 | Bahnunterhaltungs & Bahnbewachungs | | 0.66 " " 195 563 - 5 87 | 2 31 per Km 8385 4 67 |
| J 30 | Bahnhofsabfertigungs & Zugbegleitungs dienst | | 8 40 " " 448 274 - 13.50 | 6 15 " " 17 717 - 9 81 |
| J 31 | Zugforderungs & Werkstätten dienst | | 6.82 " " 364 257 - 11 00 | 2 99 " " 5 731 - 3 19 |
| J 32 | Hilfs betriebe (Services auxiliaires) | | | 4.97 " " 5673 - 3 16 |

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## *UNARMED DEFENCE.*

*By* THE FIRST TWO SAPPER OFFICERS.

WE hoped that our first article would lead to a discussion, as we thought the subject an important one. We were pleased, then, to think, on opening the December *Journal*, that blood had been drawn. Alas—it was only a red herring!

The object of our first article, which our critic confesses to having missed, was to show that the policy of disarmament became more dangerous, the more generally it was adopted. This conclusion startled us (and shocked our critic), but as we could not find the flaw in our arguments, we published them, hoping that somebody would be good enough to find it for us. Instead of this, we have been met with a set of counter-arguments, leading to the opposite conclusion. We have failed, and our critic has not attempted to find any flaws in ours, but as it is obvious that both sets of arguments cannot be sound, it devolves upon us to demonstrate the unsoundness of his. We will do our best to demolish them, although it is difficult to test his thesis fairly, as so many of his pieces are missing.

He appears to have started by searching our article in vain for a reference to the League of Nations, and, finding none, to have written his own as a footnote to ours. We erred, he seems to think, in omitting all reference to the League. Our reply is that the omission was intentional. We left the League out of the discussion of the Ruhr question—but then, so did one of the two nations primarily concerned, while the other has, so far, been left out of the League. Furthermore, the League expressed no wish to be brought into the question, so who were we to presume to do so? Our critic has now dragged it in, much, we feel sure, against its better judgment. We apologize, but it is really not our fault.

Our critic's thesis may be broadly divided into five statements:—

Competition in armaments is the most fruitful cause of war.
War will inevitably lead to the destruction of civilization.
Armies must therefore be limited in size.
Loss of defensive power due to limitation must be compensated by mutual guarantees.
This policy can only be secured by the League of Nations, which will therefore stand or fall by its success or failure in this respect.

We differ from him on all these points, but we propose to touch but lightly on the first four, reserving our heavy artillery—or should

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we say our most learned counsel?—for the last, which we regard as the most pernicious fallacy of the five.

The idea that competitive armament causes war is one that, gaining popularity owing to its inversion of a classical tag, is being lifted from book to book by our younger writers and is gradually gaining, through mere repetition, the reputation of an axiom. Its truth has never been seriously examined. The late war, we gather, was caused by the efficiency of the Russian armies, or was due to the mobilization of the British fleet. Soldiers, we understand, like being killed and wounded, and the more of them there are in a state, the stronger will be the desire of that state for war. We live, it appears, in a world of comic song, where fire insurance increases the prevalence of fire.

We deny that wars are caused by armies. Armies are merely the instruments with which they are waged. The underlying cause of every war is the clash of the policies of the governments of the nations concerned. So long as individuals are civilized there will be states, and so long as there are states these must be governed. So long as there are governments these governments must have policies, and so long as there are policies these policies are bound to clash sooner or later. As soon as a state embarks on a policy, whether voluntarily or involuntarily, inimical to its neighbour, the seeds of war are sown. The sower is the statesman. The soldier is the reaper. Armaments are not the only tools in the hands of the statesman. He only uses them when all others have failed. He makes use of diplomacy, international finance, treaties, concessions, tariffs, and possibly arbitration, before he stakes his all on the hammer and chisel of war. The tool does the work, but it does not make it.

Our critic offers no proof of his contention that wars, if persisted in, will end in the destruction of civilization. He may be right, but his statement is open to question. History does nothing to support him, but rather shows that wars are merely milestones on the road along which the human race is travelling from barbarism towards the millennium; incidents in that eternal and inevitable conflict between men and nature which we call the progress of civilization. Sometimes wars have hindered progress, as in the case of the overthrow of Rome by the Goths. At other times they have undoubtedly helped it on, as in the case of the American War of Independence. Viewed as a whole, the balance appears to be rather in their favour, but we do not insist on this point. So much for past wars. But our critic, looking into the future, says: "It seems probable that a future war, with the increased powers of destruction which the rapid strides of scientific invention will afford, would destroy our Western civilization for good." Are we, then, to abandon our proved means of defence in view of this probability, a probability

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which is not only unproved but which has already been disputed? Colonel Fuller, for instance, would persuade us to the contrary in his book, "The Reformation of War." He contends that the weapons of the future will result in wars becoming more humane. On the other hand, Miss Cicily Hamilton, in her novel, *Theodore Savage*, using weapons and tactics very similar to those conjectured by the soldier, succeeds in reducing her civilized world to ruins in the short space of three weeks. We will not attempt to improve on the arguments contained in these two very excellent books, but even if the fiction, in this case, contains the truth, our critic's corollary, "Therefore we must reduce the size of armies" belongs, we think, to a different proposition. The danger lies in the size of the war rather than in the size of the armies employed and, whatever limits may be imposed in peace on the peace strengths or mobilizable strengths of the armies of rival states, no limits can be imposed on their powers of development during a campaign without drastic interference with the very progress of civilization which it is our intention to secure. We may hope that small armies will wage small wars, but the lessons of history do not encourage us in this assumption. Rather have wars tended to become shorter with the growth of armies. The mutual limitation of armaments will neither shorten wars nor lessen their economic significance.

Wars between civilized states are not the only factors which may endanger civilization as we know it. What of Bolshevism and the Yellow Peril, to name but two? If given a chance to spread, either of these two monsters would necessitate a war on a gigantic scale before it was crushed, and such a war would be worth waging. Limitation of armaments could do nothing to prevent such a war—rather would it precipitate it. Furthermore, the initial defencelessness of the civilized world would render the ultimate slaying of the dragon a slow and painful business for the slayer. It was war that set a limit to the incursion of the Turks into Europe in 1529. It was only by fighting that the Poles prevented their country from being finally and irrevocably overrun by Bolshevism in 1920.

Mutual guarantees can never be a satisfactory substitute for self-defence. Under the old despised system of "Balance of Power" a nation limited its commitments by treaties with other powers, with the result that it only had to defend itself against certain well-defined contingencies which could be accurately measured in terms of armaments. Under a system of mutual guarantees within the orbit of a League of Nations it must be prepared to defend itself against the whole civilized world in the event of the League deciding adversely on a question which it considers vital to its existence. To those who argue that the decision of the League is more likely to be right and just than that of one of its members, we would point out that the conflict of armies is only the result of the conflict of

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ideas or ideals. Ideals have small beginnings and are usually met at the outset by tradition, suspicion, and vested interests. They can only survive and grow after a prolonged struggle against a hostile world. Which side would the League have taken, had it existed in the time of the American War of Independence, the French Revolution, or the American Civil War? Would it have helped or hindered the abolition of slavery and the suppression of the slave trade? Which side would it take to-day in an international quarrel arising out of the prohibition question? Mutual guarantees serve but to increase the gamble inherent in a policy of disarmament.

And what of the League of Nations? Is it our only hope?

We have been at some pains to distil the true essence of the League from the mass of conflicting pamphlets that have been written and speeches that have been spoken on the subject, and it was largely to avoid adding to this welter of confused thinking that we omitted all reference to the League in our previous article. But our critic was restrained by no such scruples and we are forced to accept his challenge.

Our criticism has so far been mainly destructive, but we would point out that it has been levelled, not at the League, but at the policy of limitation of armaments. What is our alternative to this policy? Let our critic prepare for a surprise. It is a League of Nations!

But let us be quite clear at the outset. The League, as we see it bears little or no resemblance to the League as he sees it. It is the same League, but the spectacles through which he views it are rose-coloured and of great magnifying power. We are even inclined to suspect that they are bifocal. Ours are of plain glass. As a result, we see the League as a gathering of statesmen, prepared to discuss such questions as may come before them. He sees further. He sees the one and only question that they must discuss and the conclusion which they must reach or perish.

We emphatically deny his contention that the League will stand or fall on the results of its deliberations on the disarmament question, and we base our denial on no less an authority than Lord Robert Cecil himself. In a lecture which he delivered to the students at Camberley in 1919 he explained that the object of the League of Nations was to promote a habit of conference and an attitude of mutual understanding between all nations, so that, as time went on, the range of questions referred to arbitration would increase and the tendency of nations to resort to the arbitrement of force would diminish. As the League, organized on these lines, gradually became an universal reality, the tendency towards *competitive* armaments would automatically diminish, because the fear of aggression would fade into the background and mutual trust would take its place. An inevitable result would be that wars would occur more rarely,

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and then would be more easily localized. In short, the limitation of armaments may come, not immediately by the imposition of the will of the majority of the nations upon the rest, but gradually by mutual consent.

Our critic looks upon limitation of armaments as a patent medicine which will cure all the ills the world is heir to, and to the League of Nations as the only chemist who can make it up. We look upon the League as a worthy apothecary, skilled in the preparation of all sorts of homely and efficacious remedies for all manner of complaints, but who refuses to make up a bottle of " disarmament mixture " without a doctor's prescription, knowing, as he does, the danger of administering strong remedies to weak constitutions. The world is a very sick man at present. He is far too sick for such drastic treatment.

The League will provide a court where grievances can be aired, discussions raised, arguments met and differences settled ; the wits sharpened while weapons grow blunter. For here is one of the pieces missing from our critic's analogy. The reason why civilians can now go their ways unarmed, discarding the weapons of their forefathers, is not that the ruffians have become less numerous or the police more so. It is because the law behind the police is stronger and more respected. Even now a police force that is not supported by the law fails to keep the peace. Our individual immunity from molestation rests on a stable government, prepared to enforce its laws. The stability of the government rests on the will of the majority of the people. The laws are therefore made by the people's will and are founded on tradition and custom. The police exist merely to prevent crime, arrest criminals and regulate the traffic.

The League of Nations cannot be compared at present to a stable government. It has no international customs or traditions to fall back upon and no international police force to enforce its decisions. It has no international courts in which to try nations whose actions disturb the international peace. It has no international code of law to administer ; no recognized scale of punishment for international offences. These defects may, and we think will, be remedied in the course of time, but, meanwhile, nations should remain, like our ancestors, prepared to protect themselves. Habits die slowly and are hard to change, and a change that is forced is less stable than one which grows. Arbitration may eventually replace armament, but it is no more an alternative to it at the present time than divorce was to the duel in the days of George III. It took over a century to convince the individual that his honour could be vindicated as satisfactorily in a court of law as at the point of a rapier. It will take a long time to convince England that its honour will be safe when entrusted to an international tribunal.

The agreements regarding the limitation of armaments arrived

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at at the Washington Conference (the only effective agreements of this nature come to since the birth of the League of Nations) were concluded by America, Japan and ourselves solely because these countries, the three largest naval powers in the world, voluntarily and for their own individual and mutual advantage, decided that a certain degree of limitation was desirable and practicable without undue risk to any of them. The League of Nations had nothing whatever to do with it. If the League had interfered, no agreement would have been reached, for America deeply distrusts the League.

The League, sitting at Geneva, imperfect and incomplete as it is, has already discussed and settled many questions generally considered as being of minor importance, such as the white slave traffic and dangerous drugs—questions the triviality of which causes the cynics to sneer and the enthusiasts to despair—questions the like of which were found large enough in the past to be the causes of many bloody wars.

Surely, we may draw the conclusion that limitation of armaments is possible outside the League of Nations and, conversely, that the League of Nations can fulfil its destiny in the world without adopting limitation of armaments as its fundamental article of faith.

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## *THE 21st COMPANY, R.E., IN THE INDIAN MUTINY.*

THE action for which the 21st Company Royal Engineers, under Lieut., afterwards Major-General, Sir Bevan Edwards, received their mention in Sir Hugh Rose's dispatch did not form part of the Battle of the Betwa, but occurred during the operations attending the capture of Calpee, from Tantia Topee, during the month of May, 1858. The action took place on the 22nd of the month and is called in some accounts the Battle of Golowlee. Sir Hugh Rose extended his force with his right resting on the Jumna and with several deep *nullahs* in front of his right flank. Soon after 10 a.m. his left and centre were heavily attacked, but he refused to reinforce those parts of his line by weakening his right, as he fully expected that these attacks were only feints and that the main attack would come from the *nullahs*. In this decision he was justified; his left and centre were hard-pressed, but the attack from the *nullahs* when it developed was successfully countered and its defeat decided the fate of the day. A feature of the operations was the appalling heat, which at times exceeded 130° in the shade. The 21st Company was in support of the right centre of the line, which was occupied by four companies of the 25th Bombay Light Infantry and half of No. 4 Light Field Battery.

The Dispatch was not written till the 22nd June; Sir Hugh Rose had had five attacks of sunstroke prior to the operations and, after Calpee, he was, according to his own words, "totally unable, although I attempted it, to compose dispatches which were to describe the remarkable operations before Calpee and do justice to the signal merits of the troops engaged." It was not published in London until February, 1859.

With reference to the reminiscence of Major-General Sir William Salmond, that the extract from the Dispatch was read out on parade at all stations where R.E. were quartered, a correspondent writes:—

The extract from Sir Hugh Rose's Dispatch, quoted in the memoir of Sir J. Bevan Edwards, and spoken of by Sir William Salmond in the December number of the R.E. JOURNAL, was published by a circular dated 27th May, 1859, from the A.A.G., R.E., at Chatham (Lieut.-Colonel E. Stanton) to Officers commanding units of the Corps.

At that time, under Field-Marshal Sir John F. Burgoyne, Inspector-General of Fortifications at the Horse Guards, there was a "D.A.G.

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for Engineers" (Colonel J. W. Gordon). Army Orders, Instructions, Circulars, etc., were minuted by him to the A.A.G. at Chatham, presumably on instructions from the I.G.F., "For circulation to companies" or "To circulate." In at least one case, a General Order on the good discipline of the troops on board a troopship destroyed by fire, the D.A.G. minuted "To be read on parade." The circular of 27th May, 1859, says that the extract "is promulgated for the information of the Corps," but the instructions from London directing the issue of the circular have not been preserved.

The Circular is given below with a copy of the Extract :—

A.A. GENERAL'S OFFICE,
ROYAL ENGINEERS,
CHATHAM.
*27th May*, 1859.

*Circular.*

The following extract, from a Dispatch from Major-General Sir Hugh Rose, G.C.B., Commanding Central India Field Force, to the Chief of the Staff of the Army in India, on the gallant conduct displayed by Lieut. Edwards, and the 21st Company, Royal Engineers, in the operations at Calpee, India, is promulgated for the information of the Corps.

By Order,
EDWARD STANTON, *Lieut.-Colonel,*
*A.A. General,*
*Officer Commanding Royal Engineers.*

"GWALIOR,
"*22nd June*, 1858.

"The enemy, simultaneously with their attack on my right, had advanced with equal vigour against my right centre, guarded by part of the 25th Bombay Native Infantry, who, despite a most gallant resistance, were driven back by overpowering numbers, which afforded an opportunity to Lieut. Edwards, Commanding the 21st Company of Royal Engineers, which I had placed in support of the 25th, to charge with his Company, most successfully, the very superior force of the rebels, routing them with loss, and pursuing them till out of reach. I beg to mention, specially, Lieut. Edwards for his prompt resolution on this occasion; he is an enterprising and promising officer.

"The 21st Company fight as well in the field as they work in the trenches, and are worthy of their distinguished Corps."

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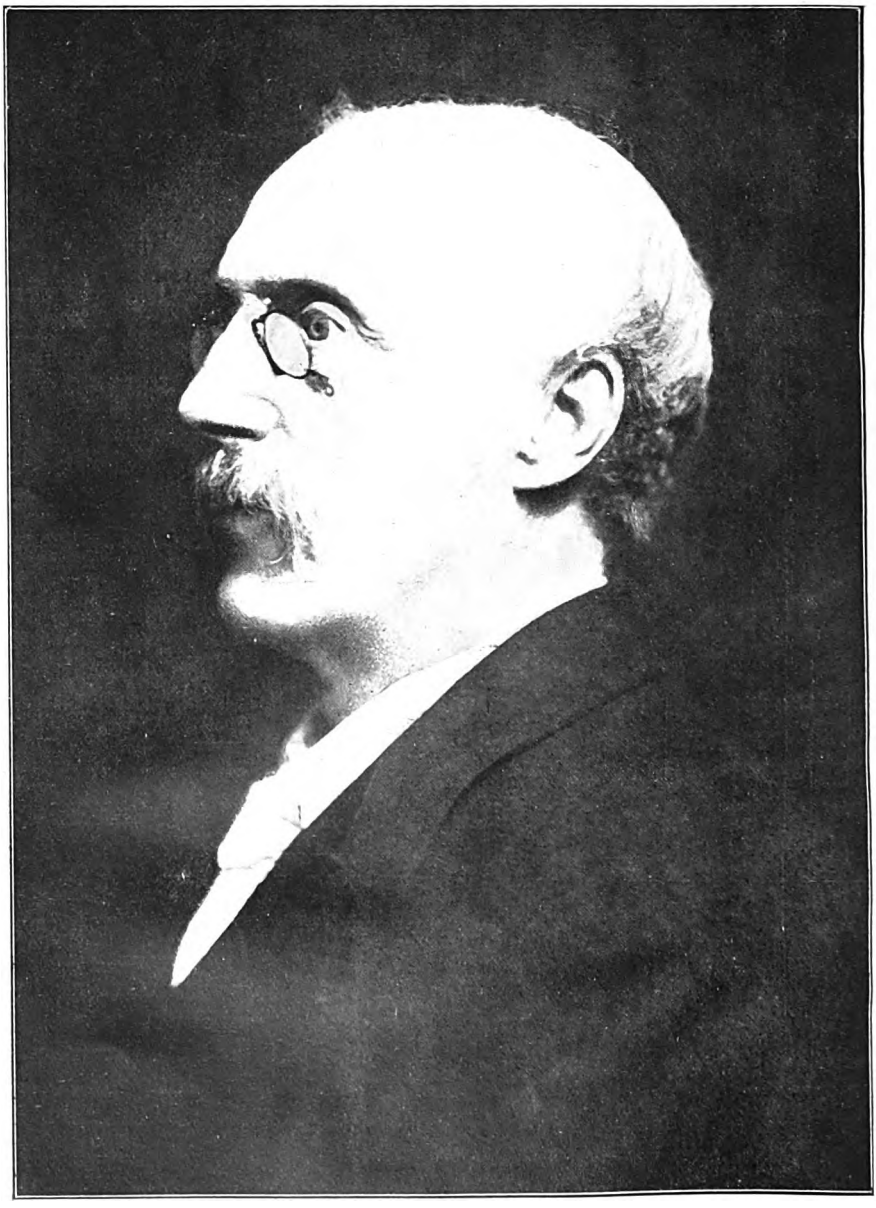

Major-General E. L. Bland, R.E.

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# *MEMOIRS.*

## *MAJOR-GENERAL E. L. BLAND.*

EDWARD LOFTUS BLAND, whose portrait appears in this number of the Corps Journal, was born in Belfast on the 10th December, 1829. He was the second son of the Rev. R. W. Bland, a member of the family of Blands of Blandsfort in the Queen's County, and Alicia Evans, of Gortmerron, Dungannon, Co. Tyrone, and a direct descendant of General Humphry Bland, who founded Blandsfort at the close of the seventeenth century. He died at White Abbey, near Belfast, on 26th February, last year, in his 94th year, the oldest of his generation of Sappers, all of whom he had survived. He retired from the Army in December, 1887, with the rank of Honorary Major-General, after service in the Corps that fell short of 40 years by 200 days only. Together with his period of retirement, 36 years, his connection with the Corps thus lasted for a period of 74 years.

He was commissioned from Woolwich in June, 1848, and served six years as a 2nd Lieut. His foreign service included periods at Nova Scotia (1851), Malta (1859), Corfu (1864), and Bermuda (1874). At Corfu his duty was to assist in the demolition of forts. At Portsmouth, soon after, he assisted in the building of a fort at Fareham, as one of the defences of the harbour. He served on the Survey of Malta, and afterwards as an Instructor of Fortification at Woolwich for six years.

His last appointment was that of C.R.E., Eastern District (1884–87). After retirement he lived first at Northam, near Bideford, and then (from 1894) at White Abbey, Co. Antrim, on the shore of Belfast Lough. For some years he did work for the Science and Art Dept. of South Kensington as an Inspector in West Cornwall and other districts.

Of a retiring disposition, he shunned publicity of any kind. His delight to the end of his life was in his garden and in the society of a small circle of friends. He had a strong artistic sense, which helped him as a photographer, a hobby in which he was an expert. A deeply religious man, he is very greatly missed in the small circle that knew and loved him. He married in 1859 a daughter of Robert Franks, of Dublin and Kilkenny, and grand-daughter of Charles Kendal Bushe, a Chief Justice of Ireland. He became a widower in 1894. He has left five sons and three daughters. He is buried in the Churchyard of Carnmoney, Co. Antrim.

R.N.B.

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## *COLONEL J. L. B. TEMPLER.*

ON Wednesday, January 2nd, passed away at Laughton Grange, Colonel James Lethbridge Brooke Templer, formerly of the K.R.R. (Militia), at the age of 78.

Col. Templer, though not in the Corps of Royal Engineers, was so closely associated with it, that he was well known to many of all ranks in the Corps.

He was the son of John Templer, a Master in the old Court of Exchequer, and was educated at Harrow and then at Trinity College, Cambridge.

I remember him, when as a boy I lived in Harrow, a tall powerful dark man whose aspect was rather stern and forbidding, but when I got to know him later in life I realized that in reality he was one of the kindest of men, who would sacrifice both time and money to help anyone in difficulties, and was most loyal to those who served with him.

He will be best known in the Corps for his services in connection with balloons, which he recognized early in life as being necessary for any modern army, and it was almost entirely due to his foresight, energy and determination that balloons were introduced into the army ; he spent not only his time but considerable sums of money in order to prove their necessity.

He was not always popular with his official superiors, as his disregard of regulations and impatience with official delays and restrictions which stood in the way of progress frequently led to conflicts with them, but in the end he generally managed to get his way and convince them that he was right.

He did a good deal of free ballooning, in the course of which he ran many risks, and on one occasion when he and others with him were being swept out to sea and the only chance of escape was to bring the balloon down and all to jump out as it touched, one of the occupants (Mr. Walter Powell) failed to jump and was lost, and another broke his leg, whilst Templer himself escaped uninjured, except that the valve line to which he clung was dragged through his hands and seriously lacerated them.

Templer was much blamed for this accident, but I am convinced that, had it not been for his skill and courage, all three would have been lost ; he did the only thing possible under the circumstances, which at least gave all a chance of life, and, injured though he was, he at once got off to a neighbouring seaport, hired a launch and did

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everything that could be done to follow the balloon to sea. It was, however, never found.

His first military work with the Corps was in the autumn of 1883, when he obtained sanction to construct a balloon and hydrogen plant at Chatham. He was given some rooms in St. Mary's Barracks and the help of a few Sappers, and I was detailed to assist him for a short time before going to India. There was constructed the first English Army Balloon, a silk one, coated with linseed oil, and christened "The Sapper," and a rough zinc and acid plant was also erected. From this small beginning ultimately emerged the Royal Air Force.

In 1885 small balloon sections were sent out to Bechuanaland and to Suakim, the latter of which Templer himself accompanied.

Later he discovered the method by which gold-beater's skin could be used for balloons and from this time on it was exclusively used, the first three dirigible army airships being also constructed of this material.

He was placed in charge of a small factory for the manufacture of balloons, the factory being later moved to Aldershot, first in the R.E. Lines, and afterwards to Cove Common, where it formed the nucleus of the present Air Craft Factory.

In the face of great obstacles, Templer made the envelope of the first English Airship, though it was finished too late for him to take part in its trials.

It was not only in Military Ballooning that Templer was the pioneer; he early recognized the importance of mechanical transport for the army, and it was owing to his energy and push that an outfit of traction engines was sent out to South Africa in 1900. The ship conveying the engines was unfortunately wrecked, but a few were later sent out and established their utility when worked under proper conditions.

Though it was not until the internal-combustion engine came into being that mechanical transport proved to be indispensable, there is no doubt but that Templer's work with the steam-tractors had awakened the authorities to the importance of its use with an army in the field.

We may look on him as the father of the mechanical transport of the present day.

Few who were at Aldershot from 1903 onwards will forget the teams of road engines and trucks that used to play in and out of the R.E. Lines, and were shown with pride to any officer who would come to look at them.

Templer remained in charge of the Balloon Factory until 1906, when he was retired on reaching the age of 60, though he was still as active and energetic as ever, and full of enthusiasm.

No sketch of his career would be complete without touching on one incident which, though most painful to him, was not in any way to

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his discredit. Whilst at Chatham, he was accused of selling Balloon secrets to a foreign government. Though everyone who knew him well must have realized that it was impossible for a man of his nature to even contemplate such an act, he had made enemies, who pushed the charges so far that he had to undergo trial by Court Martial. He was, of course, acquitted of a charge that should never have been brought, and was awarded by government a considerable sum to pay the expenses of his defence, but he felt the indignity of having to suffer in this way very acutely. His one consolation was that his trouble proved to him how many friends and sympathizers he possessed.

He married, in 1889, Florence Henrietta, third daughter of the late J. S. Gilliat, M.P., formerly governor of the Bank of England, and had one daughter.

His career was unique, and the Corps owes much to his association with it, an association which resulted in many of the officers who were brought in contact with him realizing the importance of the air and of mechanical traction for an Army.

His wonderful enthusiasm, his energy, his kindly temperament and dogged determination to push things through in the face of every obstacle, and his refusal to be downcast over any set-back, gave a great example to all who had the good fortune to be associated with him.

J. E. CAPPER,
*Maj.-Gen.*

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# *BOOKS.*

## "A FIELD ARTILLERY GROUP IN BATTLE."

By Colonel W. H. F. WEBER, C.M.G., D.S.O., *p.s.c.* Published by R.A. Institution. Cloth binding, 10s. 6d. Paper binding, 7s. 6d.

UNDER the above title Col. Weber gives what he calls in his sub-title "A Tactical Study of the 2nd Brigade R.F.A., during the German Offensive, 1918, the 100-days' Battle, and the Battle of Cambrai, 1917." One might be excused for passing by such a volume as being a form of regimental history, interest in which would be chiefly confined to those personally concerned with the unit. This is far from being the case. The book not only gives a vivid account of the fighting in those memorable days, but the author has drawn from his experiences lessons which are rendered all the more forceful since they are not purely academic.

The book appeared originally in three articles, in a series of parts, in the R.A. Journal. The first article, which covers the period of the German offensive, 1918, is divided into three parts.

*Part I.* The experience of the Brigade, which throughout formed part of the 6th Division, in the retreat from in front of Pronville right back to Bucquoy and Hannescamps.

*Part II.* Deals with the difficult days in the Ypres Salient during the German attacks leading up to the capture of Wytschaete and Kemmel.

In *Part III* the author draws some general conclusions from the fighting during these two periods.

The second article deals with the general advance in September, October and November, 1918, from the neighbourhood of Bellenglise to Avesnes, where the 6th Division found itself when the Armistice was signed.

The third article tells in somewhat less detail the story of the Battle of Cambrai, in November, 1917, from the point of view of the group which the author commanded.

Throughout the Articles, interspersed with the hard, dry details of movements, orders, and defence schemes, one finds human touches which keep continually before one the feelings and thoughts of the men taking part in the events. Frequently the Author stresses the importance of the human element in war, and he certainly does not fall into the errors of those military writers to whom he refers as follows; "Military records and descriptions of war, unless intended for the front page of a popular journal, seldom bring to the reader's understanding such things as the conditions of life of the participants; even moral, though pronounced on all sides the most potent factor, generally receives only academic notice."

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After the details of each day or phase in the operations follow comments which, while in most cases of special interest to the Gunner, are often of value to students of their profession in all arms.

The questions which receive most attention throughout the book are those of control and co-operation. The Author takes as his text in these matters a phrase from a Staff College lecture :—" Artillery must be controlled, but the principle of co-operation is superior to that of control." In this connection he, time and again, insists on the necessity of affiliated Artillery and Infantry Commanders having their headquarters close together, and suggests that, as the position of the Artillery Commander is largely dictated by communications, it will frequently be necessary for higher authority to order the movements of the headquarters of subordinate formations. His contentions are illustrated by many examples, lucidly demonstrated.

In connection with " control " Colonel Weber discusses the difficulties encountered by the Commander of a Group of several Brigades not provided with a special Staff or means of communications. He considers that up to three brigades may be grouped in this way under the Senior Brigade Commander in position warfare, but that in a war of movement any grouping is impossible without means being afforded to the Group Commander to control his subordinate brigades. The problem is one which is not peculiar to the Artillery.

The importance of a service of information, involving observation and *liaison*, receives interesting confirmation in the fact that Colonel Weber does not consider that he was overserved in this respect when he had twelve officers of his group engaged on this duty on one occasion.

The difficulty of an Army, trained and accustomed to static warfare, in adapting itself to the conditions of a war of movement is well illustrated. The pre-war trained personnel had largely disappeared and such terms as " outposts " meant little to the New Army, whose predecessors had a clear understanding of the functions of such detachments.

In *Part III* of the second Article, Colonel Weber gives his views on the " Transformations of War," to which further reference is made in his third article. Some of these conclusions may appear somewhat revolutionary, and certainly do not agree with those expressed by General Percin in " Le Massacre de notre Infanterie, 1914–18."

The writer points out that, on the Western Front, Field Artillery, both in attack and defence, was chiefly used for protection of Infantry. This task will in future be carried out largely by the tank with its own gun. He draws the inference that the importance of Field Artillery is waning, and that equally mobile weapons of heavier calibre and longer range, drawn by, or mounted on, cross-country tractors, will take over most of the duties not assumed by tanks. In his own words, " Heavy Artillery seems to be the weapon of the future, whereas Field Artillery may be one of the past ; why else did the Peace Treaty abolish the German Heavy Artillery ? "

Communications, ammunition supply, the technical training of artillery officers and N.C.O.'s, the importance of training in writing messages, are among the many points practically dealt with.

The articles are well illustrated by clear but simple sketch plans.

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Altogether the book affords very interesting and valuable reading for officers of all arms, though primarily intended for the Royal Artillery. We would welcome other similar books by Commanders of all arms. But unless these books were founded upon personal notes made at the time, there would be a danger of their lacking that human touch which constitutes one of the great charms of the book under review.

R.P.P.-W.

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## REPORT ON TRANSPORT PROBLEMS IN JAMAICA.

By Lieut.-Colonel F. D. HAMMOND, C.B.E., D.S.O., R.E.

ATTENTION has already been drawn, in the technical press, to this interesting and able Report, which reviews, in a clear light, the peculiar conditions affecting transport in the island of Jamaica.

The Report first deals with the physical characteristics of the island, which possesses length without breadth, a remarkably rugged interior, and, consequently, a large number of ports, dotted along its coast line, from which produce—chiefly the homely banana—is shipped. It is difficult to conceive a more unhappy spot for the development of rail transport. Neglecting the question of gauge, any but purely local railway development is faced with a railway's worst enemies, viz :— Heavy grades, sharp curves, short haul of light perishable freight ; and lastly, serious competition by road and sea.

It is indeed sad, as the Report indicates, that a railway of 4 feet 8½ ins. gauge should have been developed by the Government over a system totalling some 200 miles in length ; for the project, from a commercial point of view, was foredoomed to failure.

The method suggested of fixing an arbitrary capital value to the railway, for the purpose of getting a basis of comparing yearly accounts, smacks rather of lending a pleasing verisimilitude to the bald and unpleasant fact, that under no ordinary circumstances will the railway system ever pay, and it might even be suggested that the most unprofitable portions of the system be closed down.

The remarks advocating the adoption of a proper renewals fund, are of interest, as without such a fund, based as suggested, no system of accounting can strictly be considered complete.

The Report next reviews the road situation, and establishes the fact that for distances up to 30 or 40 miles, motor vehicles compete successfully with railways and that, for distances up to ten miles, even the horse-drawn dray competes successfully with motor vehicles.

Attention is next drawn to the very low cost of transport by sea in coastal boats, and, consequently, the proposal to eliminate minor ports along the coast is not advocated, and the problem reduces itself as to how produce is to be transported from the Hinterland to each port serving as an outlet.

Railways are first dealt with, and the paragraphs on " popular misconceptions in respect of narrow-gauge railways, including in that term all with a gauge of 2 ft. 6 in., or less," are worthy of attention. It is demonstrated that such narrow-gauge railways are expensive to

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operate, the cost of haul, per ton mile, being higher than with a broad gauge.

It is next pointed out that, except under peculiar conditions, the cost of maintenance is high, and the fallacy of laying a light railway along a road, is also exploded. Finally, the idea that they are better suited to hilly country is dispelled.

The significance of these remarks may be appreciated as confirming the experience gained of narrow-gauge lines, laid and operated as railways during the Great War.

The Report next discusses a number of local projects for railway development, and it is clearly indicated that, except in isolated instances, where a limited Government guarantee is suggested, they are totally unsound.

The remarks on ropeways are hardly convincing, as no mention is made of the systems adopted or tried.

The pith of the Report lies in the recommendations for the development of roads, the proposals for which are worked out in considerable detail.

The method of raising funds for road improvement, by regulating the import duty on petrol, motor vehicles, and parts, appears to be quite sound.

A.B.

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## KENT'S MECHANICAL ENGINEER'S HAND-BOOK. 1923.

Edited by Robert T. Kent. (John Wiley and Sons). London, Chapman & Hall. Price $7.00.

THE first edition of this hand-book was published in 1895. It was the outcome of advice given to the original author as a young man, namely: "Every engineer should make his own pocket-book as he proceeds in study and practice, to suit his own particular business."

Had every Royal Engineer Officer kept such a note-book it is probable that before now a Royal Engineer Pocket-Book would have been published containing information on all the subjects Electrical, Mechanical, and Structural that the R.E. Officer may be called on to tackle in the course of his career. At present no such book exists, and therefore the R.E. Officer has to go elsewhere for his pocket-book of condensed information.

Many such books are published, but most of them specialize in electrical, mechanical, or other information. Kent's Hand-book is exceptional in that it covers a wider field than most of such publications, and, in consequence, is one of the best from an R.E. Officer's point of view.

The volume contains useful mathematical tables, notes on materials and their strength, including strengths, etc., of building materials, steel and wood columns, rolled-steel joists, etc., iron and steel, non-ferrous metals and alloys, applied mechanics, heat and fuel.

There is valuable information on building construction, including foundations, roofs, floors, partitions, and reinforced concrete, etc., together with notes on heating, ventilation, and illumination of dwelling houses, factories, etc. Useful notes on Electrical Engineering are included.

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Air-compressors and Fans, Water-power and Hydraulics, Pumps and Pumping engines, Steam-power, Gas-power, Power-transmission, Ice-making, Shop Practice, Machine Design, Friction and Lubrication are all clearly dealt with. There are also chapters on Marine Engineering, Transportation, Hoisting and Conveying.

The volume measures 4½ in. × 7 in. × 3 in., and is too large to be carried in the pocket, but, considering the field covered, the book is extremely compact.

The figures are clear though small, as they are bound to be in a book of this sort. The right type of information is given, the indexing is good, and, generally, this hand-book can be recommended as one of the best published.

G.C.G.

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## MILITARY LAW MADE EASY.

By Lieut.-Colonel S. T. BANNING, C.B.E., *p.s.c.*, LL.B. (London), B.A., LL.D. 13th Edition. Gale and Polden, Ltd. Price 8s. 6d.

A new edition of Col. Banning's excellent book has just been published. It includes the amendments made in the various Regulations in the last three years, since the last edition was published, and the references have also been amended to agree with the new editions of King's Regulations, 1923, and the Royal Warrant for Pay and Promotion, 1922.

The book is therefore once more in a form which will render it invaluable to all students of Military Law, both those requiring knowledge for the administration of their units and those working for examinations, whether for promotion, or for Staff College Entrance. The author has taken opportunity to include considerable fresh matter, making room for this by omitting the Questions and Answers taken from past examination papers. These are now fully dealt with in the Reports on the Examinations published by the War Office.

Though the Table of Contents is very complete, it always seems a pity when a book of reference does not include an Index. This may have been omitted in an effort to keep down the already rather high price of the book. The references are, as in previous editions, exceptionally full and clear.

R.P.P.-W.

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## THE RITUAL OF BUSINESS.

By Major A. E. POWELL, late R.E. (Theosophical Order of Service). Price 2s. 6d.

IT may be taken as axiomatic nowadays that anyone who wishes to live an efficient, well-ordered life, and to achieve even moderate success in a career must have some grasp of business principles. This little book is therefore welcome, as it is written principally for amateurs, who have not the time or inclination to make a deep study of the subject, but who are unwilling to persevere in ignorance.

Major Powell writes in a very readable style, and gives a considerable quantity of useful information in a small compass.

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Chapter VII gives some valuable hints on office work, indexing and filing papers. As is very truly pointed out, the first essential in any system is the Methodical Mind. The chapters on Letter-writing and the Card Index are also well worth a study.

We are glad to observe that the writer insists that in all business affairs courtesy, and even friendliness, should distinguish everything we do.

In a book presumably intended for the general reader it is for consideration whether the occasional references to Theosophy are in place. With this trifling exception the book is to be commended very heartily, inasmuch as it supplies a long-felt want.

A.G.B.B.

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## OFFICIAL HISTORY OF AUSTRALIA IN THE WAR OF 1914–18.

VOLUME XII. PHOTOGRAPHIC RECORD OF THE WAR. (Angus and Robertson, Ltd., 89, Castlereagh Street, Sydney).

THIS book contains 753 illustrations, reproduced from photographs taken in almost every theatre of the war and depicting the activities of almost every arm of the three services. The reproductions are excellent and the photographs of the greatest interest. The book can be obtained in the central hall at Australia House, and a copy is being placed in the Corps Library at the Horse Guards.

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RECHERCHE GÉHYPSOGRAPHIQUE DES LOIS FONDAMENTALES DE LA DÉFORMATION TERRESTRE (1889–1921). Colonel A. Romieux (Berger Levrault).—It is regretted that a review of this reprint of articles which appeared recently in the *Revue du Génie Militaire* has been delayed owing to the illness of a contributor.

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# *MAGAZINES.*

### *REVUE MILITAIRE GÉNÉRALE.*

(*September*, 1923.)—*The Encounter Battle.* By Lieut.-Colonel Alléhaut. —Before the late war this was considered to be one of the most probable events of war. Long columns on parallel roads, covered by advanced guards with a small force of artillery, would meet, deploy, and fight a pitched battle with hardly any pause between the two operations. Now that it has been found impossible to engage with any chance of success without developing from the outset a preponderating mass of fire, this method must be modified. As the author views the course of events, the respective air forces will have approximately located the main bodies at some two days' march from each other. If both proceed, they will meet in 24 hours (case 1), or one may halt and entrench (case 2). Each then has 24 to 48 hours in which to prepare. In order to be ready, the attacker will deploy at once, first-line divisions extended with their guns ready to support them, and covered by advanced guards

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with a fair proportion of guns. Infantry and guns will advance by alternate bodies, one half ready to fire and cover the advance of the other half, and followed by the remainder of the main body as reserve. The advanced guards will proceed until checked by a solid wall of fire, when they will entrench, either to defend themselves against a superior force and give the main body time to make their dispositions, or to organize a line from which the attack will depart. The organization suggested is adapted to both the cases mentioned, the main point being the power to develop the most intense fire from the outset. It may be argued that this implies delay, but it is better to endure delay than defeat, while, if the enemy has halted to organize a defensive position, it will be possible to attack it with a minimum of further delay before his works have been completely consolidated, and he will already have had up to 48 hours in which to work.

*The Attack by the 27th Division, 25th September*, 1915. By Commandant Janet, compiled from documents of the historical service and information supplied by participants in the battle.—A clear and concise narrative is illustrated by four good maps. The attack took place between Tahure and the Buttes de Souain, and was at first successful in the centre. Owing to delays on the wings a favourable opportunity was lost of breaching the German position, and, although the action was continued for three more days, little further progress was made. The article is worthy of perusal.

*A Manœuvre of Kuroki*. By Reginald Kann.—The writer contrasts Kuroki's action at the battle of Liao Yang with that of von Kluck on the Marne. Each, when pursuing a frontal attack, disengaged a large proportion of his troops to hurl them on the flank of his enemy. But whereas Kuroki, by so doing, also aimed a severe threat on the Russian communications with Mukden, so that Kuropatkin, instead of exploiting the gap left in his opponent's line, timorously withdrew his army whilst there was time, von Kluck was dealing with a more enterprising antagonist, and even if he had been successful could only have thrown the French 6th Army back on Paris with very little effect on the communications of the Allies. He followed a German theory of war, without calculating the effects which its application to the particular case would have on the general course of the battle.

*Bibliography*.—Among the books reviewed the following are favourably mentioned:—

*Les grandes étapes de la Victoire*, by Lieut.-Colonel de Wett-Guizot (Berger-Levrault).—Written by a master of his subject and a born author, this book shows at a glance the sequence of events in the late war, its remoter and immediate motives, the reasons for them, and their consequences.

*Angora, Constantinople, Londres*, by Berthe Georges-Gaulis (Armand Colin).—A book of travels, full of interesting episodes written by an acute observer. One is struck by the spirit of design and unflinching perseverance with which England has striven to make of the Ottoman Empire a British colony, to the detriment of French interests in the country. The arguments of Turkish nationalism are precisely analysed, and an unusual portrait of Mustapha Kemal is given.

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*Souvenirs de la campagne de la Marne en* 1914. By Col.-General Baron von Hausen. (Payot).—The last of four books written by the four commanders on the right of the German line in 1914. The general does not spare criticism of the action of his own units; possibly the want of success of the 3rd Army was due as much to the health of its commander as to his Saxon nationality, which led to his early removal.

He corroborates the underlying idea of von Bülow's book, that it was the yielding of the right of the 2nd Army which caused the retirement of the whole German line. It affords an interesting insight into the weakness of the German High Command in 1914, and into faulty co-operation in the movements of the armies.

*Mémoires du Grand-Amiral Tirpitz.* (Payot.)—In spite of its undisguised effort at German propaganda this is a work of the greatest value for illuminating the history of contemporary Germany.

(*October*, 1923.)—*Ludendorff's Strategy on the Eastern Front.* By General Gamon.—A short abridgment of the course of the Eastern campaign. After briefly describing the plans elaborated by von Schlieffen and von Moltke for the opening days of the war, the serious miscalculation made by the Germans in regard to the time it would take to mobilize the Russian armies is commented upon. After the Austro-Hungarians had been thrown back on Lemberg, and the check to the German 8th Army at Gumbinnen, on 24th August, 1914, Hindenburg was sent to take command of the army, with Ludendorff as Chief of his Staff. Then follow the events leading up to, and the consequences of, their victory over Samsonov at Tannenberg, the defeat of the Austrians at Lemberg, Rennenkampf's defeat on the Masurian Lakes, the formation of the German 9th Army and the counter-offensive planned against the Russians at Przemysl. Shortly after this a copy of the orders of the Grand Duke Nicholas for the Russian offensive fell into German hands, and later on a message sent by wireless was intercepted. Hindenburg was now made C.-in-C. of the 8th and 9th Armies, commanded by Generals François and Mackensen respectively. —(*To be continued.*)

*Wakeful Nights.* By Jean Fleurier.—A collection of aphorisms and reflections on military matters, which, if somewhat pessimistic in tone, would be of interest to those studying contemporary French military ideas.

*The Attack of the 27th Division, 25th September,* 1915. The conclusion of the article by Commandant Janet.—The French advance was so far successful that it caused the Germans very grave anxiety, and a retirement was at first considered advisable, but was deferred. The reasons given for the failure to break through the German position are:—1st, the failure of the French artillery to cut the wire of the second position; 2nd, owing to bad weather interfering with aerial observation many German guns and machine-guns remained undamaged; 3rd, the disorder in the units of the division after its four-kilometre advance; and 4th, the checks occasioned to the infantry by delays in lifting the artillery barrages, due to a breakdown in the signalling arrangements. It is possible, however, that, if reinforcements had been opportunely available, further success might have been won. All these points are

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carefully examined, and the articles conclude by stating the lessons derived from the battle, which were applied later at the battle of the Somme.

*The Campaign in Transylvania.* By Capt. Salmon.—A brief account of the campaign from the invasion by the Rumanians to their expulsion by Falkenhayn a fortnight later. The general course of events and their mutual reactions are clearly brought out. At Hermannstadt Falkenhayn applied the ideas of his master, von Schlieffen, with the same boldness as Ludendorff in East Prussia and at Lodz. The strategy was rash, involving the engagement of all troops available on the spot, with few or no reserves, but met with success against Russian inertia and Rumanian inexperience.

*Bibliography.*—The following books are reviewed:—

*L'héritage napoléonien.* By Colonel Becker (Berger-Levrault).—An essay on the Napoleonic code, tracing its origin, and its effect on the development of French civilization. It is then shown that modern evolution continually demands the substitution of decentralized administration in political and social affairs for a centralized and individualist system. A few pages are devoted to internationalism, and, after expressing suspicion of the League of Nations, the colonel concludes, with Napoleon, that it is wrong to sacrifice country to idealism.

*La troisième armée dans la bataille.* By General Tarrant.—The diary of a staff officer, who, if he was an assistant and often a valuable counsellor to the generals who had the good fortune to find him under their orders, does not draw too flattering a portrait of the majority of them. Describing from intimate knowledge the life of a staff officer on field service, he leaves the impression that, at the outset of the war, the Army, Corps and Division staffs had much to learn, and, wanting method, failed to keep in touch with the actual incidents of the battle.

(*November*, 1923.)—*The German Infantry.*—In view of the possibility of another war with Germany, the writer, Commandant Pujo, deems the infantry tactics of that country worthy of study. Germany pins her faith on infantry as "the queen of battles." The article, which is well worth perusal, begins with a statement of the composition and strength of the German regiment, battalion, company and division, proceeds to consideration of the duties demanded of infantry, and then to a description of its action when on the defensive. Commencing with general principles, object of defensive action, means by which it is maintained, organization of the position, its occupation, use of features of the ground, camouflage and surprise, the disposition of the troops on the ground is explained and illustrated by diagrams of advanced posts, main defensive position, supporting points, and a sketch of an actual sector of ground occupied on these principles, reasons being given for the dispositions adopted. The general principles and conduct of the defensive action are then described.—(*To be continued.*)

*The Reverse of the Medal.*—This article, by Capt. de Gaulle, describes the want of co-ordination throughout the greater part of the war between Germany and Austria-Hungary. It might have been expected that on engaging in joint operations a German general would have been placed in supreme command, but the Emperor Francis Joseph, humiliated by

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Germany in 1866, was no admirer of William II. nor of German methods, nor had he enough influence over his army to have induced it to take a subordinate position. Than Conrad von Hotzendorf, Chief of the Austrian G.S., no one could have been more acceptable to the Germans, but he was disgusted with the autocratic behaviour of their General Staff, nor was he inclined to place implicit faith on their High Command. Before the war no plans for joint operations had been drawn up, nor did either country know the concentration or operation plans of the other. The results were somewhat disastrous and rivalry between Hindenburg and Conrad made matters worse until common disaster compelled them to compose their differences. The question of command might now have been settled, but Falkenhayn's jealousy of Hindenburg's growing reputation led to difficulties. For a time the tact of Mackensen in command of an Austro-German Army brought success, and co-ordination of effort might have brought about unity of command, when again the personality of Falkenhayn raised further obstacles.—(*To be continued.*)

*Ludendorff's Strategy on the Russian Front.*—The article by General Camon is continued, and deals with the battle of Lodz, 11th to 20th November, 1914. At the end of October the Austro-Hungarian and German 9th Armies were in a critical position, inferior in numbers to, and thrown back by, four Russian Armies which were then on the general line Kolo (on the bend of the Warthe)–Kielce. To await attack, or to make a frontal attack would mean disaster; the only chance was to make use of the strategic railways bordering the Polish salient, and deliver an attack on the Russian lines of communication by rail with Warsaw. How this manœuvre was carried out is described in this number, and illustrated by two maps. The issue was not at once so decisive as was hoped, owing partly to faulty leadership, and partly to paucity of troops, but on 6th December the Grand Duke Nicholas had to abandon the important industrial centre of Lodz, with its capacity for the manufacture of much-needed munitions, and also his contemplated operations against Silesia.

*Books.—La guerre sur le front occidental.* Vol. IX. *Les offensives de* 1915. By General Palet. (Berger-Levrault).—This new volume is said to be superior to the earlier volumes, due to numerous documents which have come to light, and of which the author has made full use.

*Le Domaine colonial de la France.* By Armand Megglé (Alcon).—This book owes its great interest to the fact that it has been written in collaboration with the agencies established in France to act as links between the mother country and her dependencies. The maps and information have been supplied by the Army Geographical Service, the Commercial office at Beyrout, and the Colonial Institute at Marseilles. Each domain is separately dealt with, and the scientific and practical utility of the work cannot be too strongly commended.

*Mémoires du baron de Schoen.* (Plon.)—The memoirs of the diplomatist on whom, as ambassador to Paris, devolved the duty of presenting the German declaration of war. At the present time, when German propaganda is displaying all its duplicity to persuade the world that responsibility for the war was not German, M. Poincaré can have no better advocate. Through the tangled mass of explanations certain

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facts stand out with startling clearness: (1) That Germany, from the dawn of the century, intended to impose her hegemony on the world, and, as regards France, to reduce her to a condition in which resistance to Germany would have become impossible. (2) The responsibility of Austria is evident. (3) Germany upheld the Austrian pretensions on the plea of her duty as an ally. (4) Germany declared war on Russia after having made insulting proposals to France in regard to her neutrality. (5) Germany declared war on France on the basis of lying allegations communicated to the French government in a partly indecipherable telegram. The ambassador looks upon his part in the transactions as the most painful memory of his career.

(*December*, 1923.)—*Historical Sketch of the French Infantry*. By Commandant Padovani.—The first two chapters of this article are merely historical, the third chapter, dealing with the infantry of to-day, is of more general interest, and gives the composition of all units from the combat group up to the brigade in a few easily assimilated paragraphs.

*Ludendorff's Strategy on the Russian Front*.—The article by General Camon is continued.—After Lodz, Ludendorff was always contemplating a Napoleonic stroke from East Prussia on the four railways leading to Warsaw and Ivangorod from north-east and east, which supplied the Russian armies. Of three rail-fed routes open to him, Mlava–Pultusk, Lyck–Bialystok, Insterburg–Kovno–Vilna, he, for various reasons, favoured the last, but Falkenhayn, preoccupied with the necessity for supporting the Austro-Hungarians in the Carpathians, would not supply the additional troops required for the wider operation, and gave orders to attack the 10th Russian Army facing East Prussia. This manœuvre culminated in the battle of Augustowo, 7th to 21st February, 1915, in which the Russian 10th Army was practically annihilated, but exploitation of the victory was not possible, as sufficient troops were not available.

The next operation prepared by Falkenhayn took place under Mackensen's command, and resulted in the capture of the bridge at Jaroslav over the San, the fall of Przemysl, and later of Lemberg, but did not achieve the decisive results hoped for. Still, Austria-Hungary was able to dispatch sufficient troops to stay the Italian front. In July Falkenhayn again wished to flatten out the Russian salient in Poland; Ludendorff objected and again proposed the attack on Kovno, but was again overruled.—(*To be continued.*)

*The German Infantry*.—The article by Commandant Pujo is continued, and this month deals with the German idea of the offensive, which, in view of the inferiority of their artillery, must be carried through by dint of superior training and courage, skill and intelligence. The conditions necessary for success are discussed at some length; plans for attack must be based on three fundamental ideas: (1) to break into the enemy's position at different places, so that the cohesion of the defence may be destroyed; (2) to ensure that the shock troops receive constant support from the heavier arms; (3) to aim at envelopment even in the smallest local attacks. The dispositions to be adopted with these ends in view are then explained, and illustrated by a diagram of a battalion attacking.

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Three phases are recognized in the attack; the advance from 4 kilometres to 400 metres, the attack and assault from 400 metres to the enemy's front line, then the fight within the position itself. The first phase only is studied this month.—(*To be continued.*)

*The Reverse of the Medal.*—The conclusion of the article by Capt. de Gaulle, tracing events on the Eastern and Italian fronts from April, 1915, to the end of 1916. Through the whole of this period Falkenhayn was intriguing to keep Hindenburg in the background, and displaying the utmost duplicity in his dealings with Conrad. The consequence was general lack of co-ordination; such disconnected operations as were undertaken failed of success owing to lack of reserves to exploit them. Thus Mackensen's success at Lemberg was not followed up; when Italy declared war Austria wished to concentrate on crushing her, but received no assistance; when Hindenburg was at length able to advance and take Vilna he was unable to prevent the Russian retreat. When Bulgaria entered the war a large portion of the Serbian Army made good its escape through Albania, and no advance on Salonica was possible, as Falkenhayn sent secret orders to Mackensen, who had been placed in command of the Balkan front, to leave the Bulgarians to act alone. It was not until February, 1916, that Conrad received any information of the projected German attack on Verdun, and, meanwhile, he had been preparing in the Tyrol an invasion of Italy, While the Austrians gained some success at Asiago, two of their armies were being cut to pieces by the Russians under Brussilov near Brody, and Falkenhayn was at length compelled to send reinforcements from the Western front, and acknowledge failure at Verdun. He and Conrad were now quite discredited, but even then the civil and military advisers of Germany hesitated to appoint Hindenburg to the supreme command. The intervention of Roumania, and the strong pressure thereupon brought to bear on the Central Powers by Turks and Bulgarians, brought matters to a head, and unity of command was at last achieved by the appointment of Hindenburg, with Ludendorff as his Chief of Staff. But in September Francis Joseph died, the young Emperor Charles quickly threw off German military tutelage, and the military convention which had been signed became a dead letter.

*Books Reviewed.—Hindenburg et Ludendorff Stratèges.* By General Buat. (Berger-Levrault).—An exceedingly interesting publication, written by one who has made a special study of the great military leaders of Germany, and based on their *Memories* and on those of Falkenhayn and Tirpitz. For two years whilst Falkenhayn was Chief of the General Staff, they were not masters of their actions, but after they had replaced Falkenhayn they themselves failed in presence of the vastly more intricate problems then given them to solve. In 1917 it was they who modified their methods. Their strategic conceptions did not expand with the needs of the situation, and effort was expended in the wrong direction. If, instead of pressing on towards Amiens in March, 1918, they had acquired comparable gains in the direction of Calais, they would have driven English and Belgians into the sea. Their ideas were too "colossal," and, when their effectives were failing, pride prevented retirement on to a less-extended front.

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*Liçoes da granda guerra. Tip. da Emprêsa Diario de Noticias.* Lisbon. By General Adriano Beça.—Written by a soldier who has already established a reputation as a technical author, this book presents in a simple and interesting form a complete compendium of the lessons of the war. The work, informed by deep experience and supported by documentary evidence, is of considerable value.

*La Marche sur Paris.* By General von Kluck. (Payot).—To von Kluck's pre-eminent reputation in the German Army was due his selection to carry out von Schlieffen's master-stroke of outflanking the French left. On 28th August, 1914, the War Lord himself congratulated his general, but on that very day came a change. The enemy retreated south-east. Thereupon to von Kluck was entrusted the two-fold mission of protecting the German right and enveloping the French left, a mission lacking preciseness which orders from the High Command that the 1st Army was to march north of the Oise did nothing to clarify. He was ambitious, hoped to secure a victory over the French, but neglected his rôle of flank guard. An order of 2nd September that he was to place himself in echelon behind the 2nd Army found him a day's march in front advancing by forced marches, and destiny, in the shape of the Army of Paris, punished his disobedience. General Debeney, who has written an able preface to the book, brings out clearly the Kaiser's responsibility in this matter. That the High Command failed in co-ordinating the efforts of the various armies is probably correct, but that does not exonerate von Kluck for failing to find out for himself the presence of Maunoury's army on the flank he was directed to guard.

A. R. Reynolds.

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*REVUE DU GENIE MILITAIRE.*

(*January*, 1923).—*Railway Engines.* The author discusses the merits of compound and simple expansion engines, the effect of super-heating, the size of wheels, number of axles, weight—describes the latest type of engine constructed for the French State Railways.

He comes to the conclusion that simplified single-expansion engines, using super-heated steam, having 4 axles with coupled wheels, give the best results from a military point of view.

*Field Telephone Circuits using bare wire.* The following points are discussed :—

1. Contact between wires due to wind or change in temperature.
2. Electrical disturbances between circuits or from extraneous causes.
3. Rapid and simple construction.
4. Ease and simplicity of repair.
5. Good results.

*Reviews.*

1. *Chemical Warfare from "The Military Engineer," July*, 1922.
2. *German Pioneers and the crossing of the Marne in July*, 1918.—No transport could approach the river without disclosing the projected attack. The plan of attack was (1) to carry boats to the vicinity of the river; (2) cross small parties of men in boats and simultaneously to commence the construction of rafts and of two boat bridges per division;

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(3) to replace the boat bridges by one heavy bridge per division. A map and a brief history of the crossing is given.

3. *The organization of positions and mining in mountain warfare*, by the Austrian Major General of Engineers Moritz Brunner.

The reviews occupy some 25 pages and are very interesting reading. For mountain warfare in high altitudes the author comes to the conclusion that only specially selected and trained troops are of the slightest use.

(*February*, 1923).—*An Essay on the problem of Communications in War in the light of the experience of* 1914–18.

The Author states that most, if not all, of the offensives in the war were brought to an end owing to the failure of communications to keep pace with the advance. He points out that the equipment, as far as tools are concerned, of divisional engineers has changed little from Roman times. He analyses the respective functions of Pioneers, Divisional, Corps and Army Engineers; points out that the first must make possible the advance of fighting, personnel, machine-guns, 37mm. guns and eventually some 75 mm. guns.

The Divisional Engineers must do as much for the Division and must make roads capable of taking loads up to ten tons for a short period of time with sufficiently good foundations to carry heavy traffic for a very considerable period. These roads would be tactical and not over well suited for subsequent collection and distribution of supplies and materials. To be of any use these roads must be able to keep up with the advance of the Division. Lateral communications, traffic circuits, etc., would be outside their scope.

Corps engineers would (1) improve the surface of divisional roads to stand very heavy continuous traffic and (2) add transverse roads and crossing places, widen roads for double traffic, make traffic circuits, etc.

Army engineers must maintain the work done by the previous formations and gradually replace them by permanent roads and bridges, which, in the latter case at all events, will probably be on different sites.

The author discusses the establishments, training and equipment required: for divisional engineers, he suggests that young men from 25 to 30 years of age are required and that they should all be trained to be skilled carpenters, this being more important than that they should be good shots. As regards equipment, he considers essential that each company should have (*a*) one or two wagons capable of being used as cantilevers over gaps, and each fitted with a pivoting crane; (*b*) carry two sets of fittings for a modified Andersen pile driver so that whilst one pile is being driven the next can be prepared; (*c*) carry a small electric winch on the platform of the crane and worked from the shore by a small electric dynamo. He emphasizes throughout the necessity for speed, also that Divisional Engineers must make one main forward road with a fair surface out of materials to be obtained locally. This road must keep up with the advance of the Division, must be capable of standing a small amount of heavy traffic up to ten tons whilst the area is occupied by the Division, and must have a good enough foundation for the Corps engineers to be able to improve the surface and so make a semi-permanent road.

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*The Ornac Bridge over the Jaur*, built by the 2nd Regiment of Engineers. This bridge was built as a peace exercise, consists of pile trestles, with the exception of three, which consist of double piers built on to concrete blocks. All expenses other than pay and rations of the working party were paid by the local authorities, as the bridge meets a longstanding need. Drawings, etc., are given.

*A Study of Mine Chambers*—Calculations are made and the shape and size of different chambers discussed. The question of detonating a charge to form a chamber is also fully considered. The *Study* is continued in the March number.

(*March*, 1923.) *Austrian Military Railway Bridges* (*Roth-Wagner Type*). These bridges are built up of standard sections and can be used for spans up to 107 metres. Joints are made by the use of bolts through cover plates or through the overlap of two adjacent members.

Only 50 different parts go to the making of the bridges and these same parts can be used to construct piers. The weights of the components vary up to 627 kilogrammes. 8 only are over 400 kg. The girder can be made of single or double unit depth, *i.e.*, 4 metres or 8 metres, and the bridge can be of either deck or through type. The author points out as a fact, and not as a criticism, that theory has been made to give way to practical results in some cases, with the result that certain components are needlessly heavy and that, in others, subsidiary stresses of indeterminable value are set up. In conclusion, he strongly recommends further study of the bridge and the obtaining of a bridge for experimental purposes. He considers that the bridge has very many excellent points, particularly in its adaptability and in the small number of different component parts. The article goes into very considerable detail and is well provided with drawings and photographs.

(*April*, 1923.) *M.D.* Battalions*, by General Protard. The author in his introduction points out that at the beginning of the war the engineers formed $\frac{1}{40}$ of the effective strength of the army and at the end $\frac{1}{27}$. The Engineer effort does not seem to be fully appreciated, and his object is to put on record the work done by the M.D. Battalions in the construction of deep dug-outs.

He describes, in the course of his article, two conveyers, one for removing spoil when working on or near the surface, and the other for use in deep dug-outs. These are extremely simple, easily portable, and require only a 3 H.P. motor. The latter can work at an angle of 66° with the horizontal. He gives details of many deep dug-outs, cut and cover dug-outs, cover necessary, speed of execution, etc. This article is concluded in the May number.

*Review. The Re-establishment of Railway Communication with the Dobroudja after* 1918.—This is a review of an article published in May, 1921, in "*Le Bulletin de la Société Polytechnique Roumaine.*" The review is in considerable detail and describes (1) the construction of a ferry-boat to take 22 locomotives and railway wagons, the ferry-boat itself being constructed out of three barges, (2) the construction of a barge bridge.

* So named after MM. Mascart and Dessoliers, Engineers, who were responsible for the special equipment of these Battalions.

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The method of loading and unloading the ferry is worthy of notice, as the river has a considerable rise and fall of tide.

(*May*, 1923.)—*Reflections of a Heretic on the Defence of Fortresses*, by Brevet Lieut.-Col. A. Clément Grandcourt. This is a paper written by an Infantry Soldier in June, 1914. It is concluded in the June number.

The author lays stress on the fact that he is neither an engineer nor an artilleryman, so that he discusses the question from an infantry point of view. He discusses the French forts in the light of past history, criticizes and suggests alterations. That he is ahead of the times is proved by the fact that he foresees the use of heavy siege-howitzers, gas, aerial bombing, etc. Many of his ideas were carried out in the war, and the only point on which he seems to have gone seriously astray is in the amount of protection required against modern artillery. The gist of the article, which occupies some 60 pages, is perhaps best given by translating the preface written by General La Croix and afterwards enumerating the points on which he lays special stress.

General La Croix says:—" . . . A wide-spread pre-war paradox denied any value to fortresses and more particularly to barrier forts. Our adversaries, by means of immediate and clever propaganda, took advantage of the costly results they achieved at Liége to confirm this paradox and so to bring about premature surrenders or regrettable evacuations. Certain people, short-sightedly coming to hasty conclusions, and without due thought, have considered in consequence that the late war has brought about the condemnation of all forts and fortresses—a serious error which might have a deplorable influence on the conservation of repair of our defences, more useful than ever against a revengeful Germany. If, as ever, offensive action eventually brought victory, the defensive, *i.e.*, the delayed offensive, showed its utility and its strength. Where would the German invasion have been checked, if Lille and Maubeuge had been organized and could have been defended as was Verdun.

It is not only the vain satisfaction of having uttered true prophecies in 1914 that has led the author to exhume this article. It is the conviction that the reader will find in it several statements which the war has proved to be well-founded and some details which the national defence might well follow. The methods proposed in this article are generally capable of rapid execution and which could have been carried out in the first half of 1914, when the electrical atmosphere made observant patriots foresee the coming storm.

The author was not correct in all his statements. Whilst foreseeing the heavy German artillery, whose destructive effect was not suspected by so many officers, he did not realize the damage they could cause. Protection is, above all, resistance to shattering by heavy howitzers rather than to penetration by direct fire. Protection against shrapnel has become of secondary importance.

Lastly, the necessity of deep continuous trenches, even for the exterior line of defence, and the uselessness and even the danger of light overhead cover soon became evident.

These errors give a date to the work, which, let it be said again, is due to an infantry man. But it seems to me that the author must be given great credit for having foreseen among others: The importance of a

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very distant line of defence, executed or rather organized in peace time (Maubeuge); the precautions to be taken against raids by armoured cars (Liége); the organization of concrete block houses (German pill boxes); batteries in casemates and camouflaged from the air; the use of rapid-fire guns of small calibre and of incendiary shell; the fight against *Minenwerfer* and against gas; the defence against aircraft and the necessity of giving fortresses anti-aircraft protection; the organization of the close defence and of keeps; finally the capital rôle of personnel, staffs and troops, played in the defence.

Owing to its date the article is not a criticism of the late war; if it is, it is that the war has proved its soundness. In it are found the proofs that the German methods did not come as a surprise to those who were able to look ahead and who had taken the trouble to study. It is not, therefore, in spite of its date, but because of its date, that I recommend the following pages to the military reader."

In his summary the author states that he has tried to draw attention to the following points:—

1. The immense importance of the outer defence organized in depth;
2. Necessity for the complete protection of the fixed artillery and the development of the mobile artillery;
3. Permanent works to be a protection and not tombs; construction of keeps;
4. The use of woods in defence by means of "Pirate Forts";
5. The rapid supply of heavy long-ranging guns, if necessary by borrowing from the navy;
6. The increase of small medium-calibre artillery for use against personnel;
7. Special arrangements against assault;
8. Anti-aircraft defence;
9. Field and fortress troops to be interchangeable;
10. Increase of staff officers.

*Log Bridges for Heavy Loads.*—The Rhine having always a large number of felled trees floating down to the saw mills, the author describes types of rafts and bridge piers constructed from these trees and experiments with them. Such rafts offer the maximum of resistance to artillery fire as, unlike pontoons, they cannot be sunk.

*The Utilization of the Waters of Morocco.*—The author deals briefly with the water situation in Morocco and describes the arrangements at one post for supplying the troops and the native village with water. An improved Hydraulic Ram (the Bollée) is described.

C.LAT.T.J.

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## *REVUE MILITAIRE SUISSE.*

(1923. *Nos.* 10 *to* 12 *inclusive.*)

Certain military writers attempted during the early days of the Great War to draw conclusions as to the value of permanent fortifications from the press accounts which were given of the part played by fortresses in Belgium, France and Russia; the verdict of these writers was that the advent of Heavy Artillery, such as that brought into the field at

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the outbreak of war in August, 1914, had sounded the death-knell of permanent fortifications and that the experiences on the Western Front, as well as on the Eastern Front in Europe, all tended to expose the bankrupt condition of this form of defence. M. Jean Fleurier contributes an article to Nos. 10 and 11 of the *Revue*, which is of particular interest to Sappers; he combats the views of the writers referred to above and points out that the first accounts published as to the part played by permanent fortifications were sensational and misleading. He is of opinion that the deductions drawn from the photographs of the forts damaged by the German artillery were altogether erroneous; these photographs, it should be mentioned, were taken by the Germans for propaganda purposes. In recent times, a considerable number of books have been published by authors who have had an opportunity of personally making a critical examination of the effects of the German Heavy Artillery on the important defences in Belgium and in other countries. The information now made available is of such a character as to render necessary a complete reversal of the early opinions formed as to the value, or rather as to the alleged uselessness, of permanent fortifications. The impression, which gained currency in the autumn of 1914, that permanent works have no resisting power against heavy ordnance can be traced to the deliberate measures taken by the German High Command, as a part of their *manœuvres morales*, to spread the notion that the destructive effect of the projectiles, fired by the weapons designed and constructed at the Krupp and Skoda factories, was so enormous that no Entente fortress could hold out against them for more than a few days at most in the face of an artillery bombardment conducted with the vigour shown by the Germans at Liége. M. Fleurier admits, of course, that very important results were obtained by the German Heavy Artillery, but he points out that the regular sieges of the Great War, and the defence of Verdun in 1916 in particular, all teach that permanent works, when in the hands of those who know how to get the fullest advantage out of them can still be relied upon to play an exceedingly valuable rôle in modern warfare. The course of events on the Western Front and those on the Eastern Front are separately set out in outline in the original article. It is quite obvious from these brief surveys of the war that the results obtained by the German Heavy Artillery had very far-reaching consequences; these results were partly of a moral and partly of a strategical character. The intensity of the German bombardments produced in many cases so great a demoralization in the defending troops as to induce a "voluntary abandonment" of fortified centres. M. Fleurier is of opinion that the too ready abandonment of permanent works can be traced very largely to the mischievous doctrine preached before the war to the effect that "ground in itself has no real military value." It was for this reason that, in the first days of the war, no serious attempt was made by the French Armies to make a stand on the strong positions on the Northern frontier of France, positions for the defence of which projects had been prepared by Seré de Rivières. Later, during the period 1915 to 1918, exceedingly costly operations were undertaken to drive the Germans from these very positions. In the second part of his article, M. Fleurier

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probes the situation with a view to ascertaining the causes which were responsible for the extremely disappointing part played by permanent fortifications—the enquiry deals mainly with the Belgian theatre—and records his conclusions: briefly, in his view the Meuse fortifications were so placed as not to meet the strategic requirements of the situation; they were not only too close to the German frontier but the works were also wholly inadequate; no permanent works existed at 9 out of the 29 points of passage across the Meuse, and the undefended gaps were so wide that the Germans were able easily to push past the fortresses of Liége and Namur without let or hindrance. M. Fleurier shows conclusively that, so far as the Meuse defences were concerned, they failed to meet the requirements of the situation in three important respects, namely, (1) the works were insufficient in number and disposition properly to bar the lines of advance from Germany into Belgium; (2) the Belgian artillery was insufficient in number of pieces and also in calibre to cope with the German Heavy Artillery; and (3) the number of troops available for the defence of the Belgian Eastern frontier was insufficient effectively to guard the whole extent of the line which should have been held in order to oppose properly the German advance into Belgium. In addition to the foregoing defects, the Belgian High Command was faced with the anxiety arising from the fact that the Belgian fortress troops were of poor quality and their officers without experience. The doctrine that any kind of troops, and, particularly the view that men not good enough for service with active units and formations, were quite suitable for the defence of fortified centres, had not yet been exploded on the Continent.

Among other contributions to the numbers of the *Revue* under notice are articles by M. R. A. Jacques dealing with the design of bombs for the use of the Air Force (in No. 12); an account of the recent retreat of the Hellenic Army in Anatolia (in No. 10); and extracts from the private diary of M. Louis Rambert, wherein events connected with the Greco-Turkish War of 1897 are touched upon.

W.A.J.O'M.

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*BULLETIN BELGE DES SCIENCES MILITAIRES.*

(1923. *Nos.* 11 *to* 12.)

The account of the operations of the Belgian Army is continued, some of the events of October 4th and 5th, 1914, being dealt with in the two numbers of the *Bulletin* under notice. The text of the communication addressed by the Belgian War Minister to the British First Lord of the Admiralty and also the text of the telegram sent by the British Foreign Office to the British Legation in Antwerp on October 4th are set out *in extenso*. In the former, the Belgian War Minister conveys the thanks of his Government for the reinforcements sent and the further reinforcements promised by the British Government; the latter repeats the text of Lord Kitchener's message to the First Lord of the Admiralty, wherein are given the particulars of the Expeditionary Force, amounting approximately to 53,000 men, being sent from England and France to the relief of Antwerp. The anxiety of the Belgian High Command, in relation to

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the protection of the line of retreat from Antwerp to the coast, is clearly revealed in the Belgian War Minister's communication of October 4th; a request is made that the British troops promised by Lord Kitchener, namely, the 3rd Cavalry Division and the 7th Division, should be directed to Ghent as quickly as possible, in order to ensure that the Belgian Field Army should be able eventually to join up with the British and French Armies. The intention of the British Government was to land its quota of the reinforcements being sent to Flanders at Zeebrugge. On the other hand, the French Commander-in-Chief was asking that the 7th Division should be disembarked at Boulogne, in order to join up immediately with the British II and III Corps: his intention being that the British Expeditionary Force should quickly extend its left flank northwards with a view to turning the enemy's right and *thus to join hands with the Belgians*. Sir John French was in accord with the French Commander-in-Chief and supported his proposal. The British Government was not, however, to be moved from adopting the course it had indicated to the Belgian Government as being in process of being carried out; the 3rd Cavalry Division and the 7th Division were conveyed from Southampton to Zeebrugge on the night of October 4–5th, the Admiralty having taken steps to ensure the safety of the transports; at the same time, two brigades of the Royal Naval Division were dispatched from Dover to Dunkirk. Having received an assurance on October 4th, that 22,000 British troops and 23,000 French troops would be landed immediately on the Flanders coast, the Belgian High Command felt less apprehensive as to the safety of the Belgian Field Army, but it was still uneasy as to the movements reported to be taking place westward of the longitude of Brussels. Intelligence received in Antwerp indicated that German forces were already marching from Tournai on Lille and that an action had been fought northward of this line, namely, in the neighbourhood of Audenarde. In consequence, Belgian cavalry, cyclists and machine-guns were hurried to Ghent; clearly, the anxieties of the Belgian High Command were by no means entirely at an end. The view was held in Antwerp that St. Omer, the point at which the concentration of the British Expeditionary Force was now being effected, was really too far to the westward of Lille to enable the British troops properly to cover the retirement of the Belgians from Antwerp to the coast; the Belgian High Command expected that any move made to the northward by the British for the purpose of extending the Entente left towards the Dutch frontier would certainly be met by a vigorous counter-move on the part of the Germans, who would naturally guard against any attempt to turn their outward flank. The prolongation of the German front to the northward would, it was felt, seriously imperil the Belgian Field Army. In these circumstances, the Belgian King made further representations to Colonel Bridges, the British *Liaison* Officer at Belgian Headquarters, and requested that instructions should be issued to ensure that, in addition to holding Ghent with the 7th Division, the British should occupy other points on the line of retreat from Antwerp with additional troops to be provided for that purpose. At one time, the Belgian High Command appears to have entertained the hope that the position in Belgium would have been made so secure

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that it might have been possible to hold the Germans on the line of the Scheldt between Ghent and Audenarde and thus have prevented them from reaching the coast. But the Germans had pushed forward with almost reckless speed, so that by the morning of October 5th not only had the Belgians been driven to the north of the Nethe and out of Lierre, which was now in enemy hands, but advanced parties of Germans had reached both Termonde and Schoonaerde, whilst their reconnoitring parties were known to be in the neighbourhood of Sotteghem.

A short while back it was announced in the Daily Press that a recent invention made in Germany provided the means whereby the engines of aeroplanes, of airships and of automobiles could, from a considerable distance, be brought to a stand-still whilst in operation. The possibility of such an achievement being within the range of accomplishment by human beings was received with incredulity in some quarters; indeed, it was even held up to ridicule. M. H. Dackweiler contributes an article to No. 12 of the *Bulletin* wherein he suggests that those who have cast ridicule on the alleged invention would have been better occupied, had they, instead, devoted their time and their intellectual equipment to the task of attempting to discover the secret of the mechanism by means of which such a result may be obtainable. M. Dackweiler calls attention to the early experiments of Tesla with high-frequency currents in 1898, and points out that the distinguished American scientist little anticipated at the time how serious would be the consequences resulting from these experiments; the electro-magnetic radiation from his laboratory provided sufficient energy, at a distance of some miles from the locality of its generation, to burn out the powerful dynamos at the Power House of the Colorado Electric Light and Power Company. M. Dackweiler provides, in simple language, an explanation of the effects produced by high-frequency electric currents and points out that, since in modern internal-combustion engines used for propelling aircraft and mechanically-driven vehicles the " mixture " is usually fired either by means of a magneto or an induction coil, the problem of putting the engines of an aeroplane or an automobile out of action resolves itself, in such cases, merely into a matter of generating sufficient heat in the armature windings or in the windings of the induction coil to fuse the wire forming these windings. The problem of disabling such engines is by no means difficult of solution, so long as existing methods of ignition continue to be employed. However, it is foreseen that, the danger being indicated, counter-measures are likely to be adopted and it is anticipated that in due course the present-day types of engines in aircraft and in mechanically-propelled vehicles will be replaced by types which are not similarly vulnerable.

Other articles in the numbers of the *Bulletin* under notice deal, *inter alia*, with the mistake the Germans made in violating the neutrality of Belgium and the serious consequences that followed thereon (No. 11); the conversion of solid into liquid fuel (Nos. 11 and 12); the American Civil War (Nos. 11 and 12). Considerable information relating to the Air Forces of various nations is contained in Nos. 11 and 12 of the *Bulletin*.

W.A.J.O'M.

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*MILITÄR WOCHENBLATT.*

(*15th April*, 1923.)—In a leading article on military-political conditions in South-West Europe, von Winterfeldt commences by observing that the relations of the states of the Little Entente to each other and to the other countries not belonging to this Entente are of so many and opposing shapes that South-West Europe, as of yore, will remain the storm centre of the Old World.

" Even though they may be intent on pursuing their own policy, they are always confronted by their dependence on France. Their other common interests as against Hungary continue to keep the Little Entente firmly united."

He then proceeds to take the various states in turn. Czecho-Slovakia is said to be completely under French influence ; the French military mission, the head of which is at the same time Chief of the General Staff, has occupied the chief positions as regards organization, training and leading, so that the Army has been put almost entirely at the service of French interests. " Co-operation with France in the event of any further sanctions is as good as secured. In such an event the further occupation of Silesia and an advance from the neighbourhood of Eger against the Main appear to have been prepared." The Germans in the Army are said to be systematically kept back, and even gradually replaced. The writer insists that Czecho-Slovakia is a French vassal-state, whose army is at the disposal of the French till 1929, and that France can dictate not only its political but its military action against Germany.

Rumania, Serbia, and Austria are then dealt with, the main point being that their armies are not up to a high standard. Hungary, however, though small and still weak, is eulogized for its national ardour and patriotic feeling, which is particularly noticeable in the army, whose value is rated highly. The army reductions, as stipulated by the Treaty of Trianon, have been completed. The Chief of the Entente Commission, the Italian General Zucarini, carries out his work " with benevolence towards Hungary."

Finally, as regards Bulgaria, it is observed that, while universal service has been suspended through the provisions of the Treaty of Neuilly, there are still great gaps in the army, as volunteers are not forthcoming in anything approaching the numbers required.

(*1st May*, 1923).—Under the heading " Nauticus redivivus " the leading article of this issue welcomes with enthusiasm, and sentences of colossal length, the reappearance of this German naval annual. After a lapse of nine years a new volume has appeared, smaller but " supported by courage and confidence and, like its predecessors, endeavouring to tell the German nation about the sea, which for the great part carries its bread and its—*ach so knapp gewordenen*—wealth, the means of support of its life."

The 1923 Annual has set itself the task of answering the question, " What was, and what to-day is, striking the balance between the losses of the war and the value and strength of the present and the future ? " Questions of naval power and politics are left to a secondary position, and trade, technique and navigation are the first consideration.

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In a military-political review of the general world situation, " Lucius Cincinnatus " devotes the first column to violent criticism of the French, and encouragement to his countrymen in their struggle to maintain passive resistance. Turning to America, he begins with the curious remark that " since Wilson so thoroughly decoyed the German Michael into a trap," no support is to be looked for from America for a long time against French overbearance. After remarking that the mass of the American people take no interest in Germany's fate, he goes on to the oft-repeated statement that the Entente owe their victory to the American assistance, adding that it can be understood that neither England nor proud France are willing to admit this truth.

" In England there has undoubtedly taken place a certain revulsion of feeling in our favour." Comment is directed to the extensive propaganda campaign in favour of France, at the head of which is the *Daily Mail*. In spite of this the upper classes are beginning to realize that it was a mistake to weaken Germany to such an extent. The lower classes are " incapable of political judgment " and allow themselves to be led. " But if the English do not feel in their own persons the disadvantages caused them by French imperialism, they will do nothing for us." He then says that our diplomacy is hampered by our weakness on land and in the air, and so introduces a comparison of French and British air forces. He then quotes from a report on the air forces by Colonel Girod, member of the Army Commission in the French Chamber, who points out that England has lost her isolated position as an island by reason of the danger of attack from the air. This the writer describes as intimidation of England, and then says that England can also certainly cause her " former friend " considerable anxiety, particularly in the Colonies. The paragraph concludes: " However, it seems exaggerated to deduce from an undeniable cooling-off of the friendship that England, in the near future, may take any action in Germany's favour." The concluding paragraphs of the article deal with Italy, the Lausanne Conference, Egypt and India.

It is interesting to observe that in this, as in former similarly entitled articles, the same propaganda are being developed; abuse of France, resignation as regards the U.S., ridicule of England's apparent helplessness, and emphasis at any cost of any and every sign of weakness of allied unity. A further indication of these motives is to be found in that portion of the issue where recent publications are reviewed. Here prominence is given to what appears to be a mere pamphlet written by the French Colonel Gauthier, entitled " L'Angleterre et nous "; the review begins by saying that the author sees in England an open enemy, whose enmity dates from the Peace Conference in Paris. The rest of the review is a translation of what would seem to be the most violent sentences to be found in the pamphlet—good copy, in fact, for the man who wishes to preach from the text that the *Entente* is dead.

(*15th May*, 1923.)—The new Base at Singapore is discussed in this issue; the writer dates the inception of the scheme back to 1919, when " the English Government, by the increasing apprehensions of the Dominions in the South Sea before the Japanese danger, saw itself forced to submit the strategic situation in the Pacific to a close examina-

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tion," and for this purpose sent Admiral Lord Jellicoe on his mission. This preparatory measure is said to mark the close of one period of measures of security for the English World-Empire, and the beginning of a new one. " The great programme of the English World-Empire, a programme necessitating the defeat of the German, Russian and Japanese dangers, in order to secure the stability of the empire, was approaching its third act. The period of history just ended, which had necessitated the concentration of English naval power in the waters of the North Sea, appeared to be closed, the European situation secured, and the East Asiatic ripe for action." Japan's position in the Far East, her intentions towards China, demanded a new orientation of English policy, which led, in agreement with the United States, successively to the renunciation of the Anglo-Japanese alliance and the summoning of the Washington Conference.

The writer then speaks of Lord Jellicoe's proposals to station eight battleships and eight battle-cruisers in the East, which were dropped partly on financial and partly on diplomatic grounds. The Washington Treaty having settled not only the limits of naval strength, but also the question of fortified points in the Pacific, the new requirements of the situation would be examined. After detailing the provisions of the treaty as regards fortified places, the writer observes that Singapore was not affected by these limitations and the English plans could take a firmer shape. The importance of Singapore is then discussed both from its geographical and economic aspect, its importance being compared to Gibraltar or Panama. " A military base for a fleet at this point means a stronghold for the freedom of the seas of the most genuine type." After paying some attention to the arguments put forward by Mr. Amery, the writer concludes: " The new step is for the moment without deep significance for the European situation. The subjection of English policy through the superiority of French military and air power remains unchanged. There only remains to acknowledge the grandeur of the political conception which, unaffected by such subjection, already undertakes the necessary measures to meet in a period of years the new tasks properly prepared after the European questions have found their solution in one way or another."

(*10th June*, 1923.)—The leading article of this issue deals with the " Military-Political " situation in France. The writer starts by asserting that the readiness for self-sacrifice which the French nation showed before the Great War in order to furnish the necessary military forces for defence still holds good in undiminished measure. The *leitmotif* is unchanged: Security against Germany. " Our total disarmament is overlooked." The alarming, " though inaccurate," reports of alleged frauds with regard to German army strengths are thoroughly exploited. France's love of peace is continually emphasized, but Germany's desire for revenge, her intention to utilize the *Reichswehr* and the *Schutzpolizei* with, in all, 250,000 men as *cadre* for a huge army, aided by the regimental associations, hidden stores of arms, help from Russia in the shape of war material of all kinds—the writer adds a mark of exclamation here—all this prevents France from reducing her army. " There is no more talk of the stipulation of the Versailles treaty that Germany

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should first get on with her disarmament and that the other powers should then follow suit."

The writer then deals with the army and navy estimates of France, her failure to balance her budget, and her war debts, in order to point out the financial difficulties of the French Republic. He then proceeds to deal with strengths, and passes on to discuss the effect of the falling birthrate. The invasion of the Ruhr, culminating in the verdict at the Krupp court-martial, is next dealt with, followed by a paragraph pointing out the various military problems that France has yet to solve. The writer gives the French peace effectives, and lays stress on the great development of the air forces, which in peace should total 20,000 men and develop a war strength of 300,000. " But in spite of this superiority an airman of repute has bitterly complained in the Chamber about the defective and antiquated machines and the need for improved engines. In reply, the Government pointed out that the French aircraft industry constructed 3,000 new aeroplanes in the first eleven months of 1922. This should give England something to think about. Precisely in their superior aircraft industry has France got an effective weapon."

"The Paralysed German General Staff" is the title of the next article, dealing at considerable length with Professor Delbrück's accusation in the *Berliner Tageblatt* in April last. The professor was writing on the subject of Field-Marshal Count Waldersee's memoirs, which had recently appeared, and the sentence forming the text of this article is as follows:—" The point is the extraordinarily momentous question whether the German General Staff was paralysed in a barren dogmatism, having as consequence the loss of the World-War and the fall of the German Empire, and whether this paralysis had already set in with Moltke's immediate successor, Waldersee." The controversy is only another phase of that between the politicians and the military party as to who lost the war. After saying that the complaint can be directed with less justice against Waldersee than against Schlieffen, " the spiritual creator of the march to the West," the younger Moltke and their disciples who filled the leading positions in the war, the writer then has a general slap at the politicians who supported Bethmann. He propounds two questions to be answered in order to refute Delbrück's thesis :

1. Did the general staff do everything before the war in order to produce in the German Army, by means of organization, armament, internal development, moral and practical education, an instrument which would be capable of undertaking all the heavy tasks that it would encounter in war, or not ?

And 2. Did the German General Staff before the Great War do everything in the practical and theoretical education of general staff officers based on their own and foreign, past and recent, war experience, to fit them in the spheres of both strategy and tactics to meet, not only in the superior but in all positions, the many-sided and often antagonistic tasks in the West and the East ?

The first question he answers by saying that Marshal Foch, who is regarded as the greatest commander of these times, has himself called the German Army of 1914 " the best army in the world."

The second question is not so quickly disposed of ; a column and a

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half are devoted to its treatment, and finally the question is asked: "Why had the Entente at Versailles nothing more urgent to do than to extirpate the German General Staff?" Keynes is quoted as saying that it was the German terror which overhung them, and this terror was first and foremost the German General Staff. The article then resolves itself into a countercharge against the politicians for the loss of the war and the downfall of Germany, on the same lines of argument that this journal has been following for many months past.

Under the general news at the end of this issue is a short paragraph quoting a story from Mayence, published by the *Kölnische Zeitung*. A "nigger" suddenly appeared in the street there, naked except for a meagre leather apron. His appearance attracted a crowd and two policemen. Both were at once scandalized, but with inborn German courtesy they first enquired of the "nigger" why he was promenading the streets in this primitive attire. Thereupon the "nigger," grinning over his whole face, opened his enormous right hand, from the hollow of which a white paper made its appearance. On the paper was written, over the stamp of the French military headquarters in Mayence: "The negro Bambula has leave. He is permitted to wear plain clothes."

(*25th June*, 1923.)—The only article of interest in this issue is a review of a French Book on the "Battle of Montdidier," as the French call the battle on the 8th August, 1918, and following days, which was won by the British Fourth and French First Armies. After observing that Marshal Foch, in his instruction of 24th July, 1918, had emphasized the supreme importance of surprise in further operations, the critic says that the Germans were well aware of this principle; that up till July they had succeeded in obtaining this element of surprise; "on 15th July it failed. On the 8th August the English and French succeeded in a complete surprise. The measures taken to this end correspond so exactly to those hitherto adopted by us that it almost looked as if German orders had served for examples." After quoting several of the steps so taken, he then says that the most important and decisive means whereby the surprise was obtained, "a means that unfortunately was not at our disposal," was the employment of tanks. The course of the battle, as described by the French author, is then shortly described, before the critic deals with the statement that one of the chief causes of the German defeat was the separation in the German Army of divisions for attack and divisions for position warfare. The critic says that this was only a policy of necessity, owing to the German difficulties in replacing men and horses. "Of there being a German system, which was inferior to a better French system, there can be no question." Finally the critic finds in the French author a supporter of the German policy of wholesale destruction during retreat, a policy that the French condemned as barbaric and contrary to international law. "Armies of to-day have so many needs in order to live, move and fight, that a thorough destruction of means and communication of commerce strikes at its most sensitive spot and can completely paralyse it." The critic seems to overlook the difference between normal military measures and those that were considered barbaric.

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*HEERESTECHNIK.*

(*October, November and December*, 1923, *numbers.*)

*Anti-Aircraft Defence.*—The article by Major Gretsch is continued in the October number and deals with searchlights. Searchlights, to be of value, must have a mirror diameter of over 60 cm. They are generally used in batteries of four, and their distribution is dictated by that of A.A. batteries. There should be at least 500 metres between searchlight and guns, however. For the defence of a town or area at least two lines or circles of light must be used. The outer to pick up, and pass on to the inner, any raiding planes. The inner ring should be so disposed as to be able to cover the whole area up to an altitude of 3,000 m. Lights from fixed points may serve eventually as navigation lights to raiding planes. Positions should therefore be altered.

Major Gretsch does not believe in balloon or "sausage" entanglements (such as were used in Paris). He states that their use in Germany was responsible for only one solitary casualty to allied aircraft, that it is very costly in men and material, and is as dangerous to friend as to foe.

The principal task of civil and military co-operation is the organization of an efficient observation service to report all movements in the air. The first use of this system is to give scouts sufficient time to reach their full height before the arrival of bombers, but it may also be necessary to track down spies (put down by aircraft), and also information (and propaganda) dropped, may be collected. An organization is described which groups a few observers under a report centre and a few report centres under an information centre. Communications should be by separate and reserved telephone lines amplified by wireless. Scouts need twenty minutes at least to get their height and therefore the first news should come in when bombers are about 100 kms. distant. From this fact it is deduced that no sufficient protection by fighting planes can be arranged for in the case of towns which are within 50 km. or so of the enemy lines.

Not much weight is laid upon camouflage or upon dummy construction. A few general remarks indicate how valuable it would be to deceive raiders, without indicating how it may be done. Civil precautions should aim at preventing panic by giving civilians a clear idea of how and when to act.

The effect of the growth of artillery fire upon the character of fortified towns is referred to and the opinion is expressed that the town of to-morrow may be designed in some new and startling way in order to escape the dangers which threaten from the air.

*Rivers in Battle.*—Major Klingbeil resumes his explanation or *précis* of the new training manual *Brückenbau* or bridging. The first cases quoted postulate an undisputed crossing with a possibility of fairly speedy counter-attack. The value of speed, good staff arrangements (*i.e.*, early arrival of engineer and bridging units, etc.), and well-arranged supporting artillery and machine-gun fire are noted.

If the river is already under hostile observation, success will probably only be achieved by night or in poor visibility and must be prepared for very carefully. Camouflage, and well-staged feints, accompanied

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by thorough reconnaissance and good arrangement, will be essential. The operation will be carried out by covering troops, which provide covering and supporting fire, advanced troops (apparently rafted over, because the preparation of such rafts is emphasized), and a reserve, by which working parties are formed. The necessity for silent approach on straw or manure-covered roads, and for hiding from air observation the bridging material, and preliminary ground work, is emphasized.

We next reach the " ultimate case " of a frontal attack on a strongly-held river line. Everything is to be put in, in such a case, and, of course, with every possible element of surprise. The supports for the pioneer troops immediately engaged on the job should rise to 50 per cent. and every article of equipment doubled. Woods and copses, certain targets for artillery, are to be avoided ; covered approaches, perhaps through wide trenches, are to be made. Other pioneer formations are to stand by to undertake repairs, to alter position, or to dismantle, as occasion demands. Pontoon bridges are to be replaced by more permanent forms, capable of carrying heavy loads, at the earliest possible moment.

Bridging in a retreat must be of solid character and provide for crossing on a broad front. Crossing should be at night or under cover of a smoke-screen. Artillery will cross early and cover the operation. Dismantling or destruction to be arranged for. Loss of pontoons is excusable, if troops are saved.

In the defence of a river front counter-attack must find its place, and implies crossing at some time or another. The most important factor is reconnaissance. The line of resistance is the river bank, or outpost line. The rôle of pioneer units is technical reconnaissance, destruction or hiding of all boats, and the preparation of floating mines, etc.

In approaching a river the vanguard pioneers must be strengthened and pontoons must be brought forward by night marches, arranging for their camouflage by day.

A special article deals with rafting or ferrying, and another with the subsequent bridge construction, giving figures and calculations. These emphasize the necessity for a sufficient strength of pioneers—approaches to be marked with signposts which can be illuminated at night.

Camouflage and anti-aircraft precautions are dealt with at length. The main job of A.A. batteries is to cover the whole space over the bridge with fire and to watch the natural avenues of approach (above railways, roads, canals, etc.). Smoke-screens are more likely to help by attracting hostile fire on unimportant places than by actually vitiating aim.

*The Influence of Temperature and Wind on the Velocity of Sound in Air.*—This paper, by Doctor Kolzer, deals with the phenomena of the propagation of impulsive sounds in the atmosphere, and particularly with the fact that sounds are sometimes heard at great distances from the source (zones of abnormal audibility), although inaudible over intermediate areas (zones of silence).

The author quotes the work of a number of investigators, notably Tyndall, Mohn, Borne, de Quervain, Mölke, and particularly Emden.

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(Contribution on the thermodynamics of the atmosphere, in Vols. 1–6 of the *Meteorological Gazette* for 1918.)

An explanation of the observed phenomena is found, which confines the problem to the " Troposphere."

This is opposed to the theory of Borne, which regarded the energy reflected from the hydrogen layers of the upper atmosphere necessary to account for the zones of abnormal audibility.

Equations are given for the paths of sound rays (normal to the wave front) in terms of determined meteorological quantities, and the work includes diagrams of the boundaries of the Zones of Normal Silence, and Abnormal Audibility in three dimensions, taken from Emden's work, and connected with Stated Meteorological Assumptions.

There are numerous compositors' errors and the text is difficult to follow in consequence.

The paper is not yet complete and its conclusion will be reviewed later.

*Angular Measurement.*—A short article summarizes the different sorts of angular measurement still in current use in the German Army. What with the *Feld Artillerie Strich*, the *Fuss Artillerie Strich*, the *Sexagesimal* and the *Centesimal* systems, one would have thought there were enough to choose from, but there is also given a sexagesimal beginning with quadrants of 90° followed by a centesimal division into minutes and seconds. A captured log-book on this principle caused us some consolation in France, for how can a nation which employs no less than six different systems of angular measurement, alongside each other, throw stones at our barleycorns and perches? Perhaps the idea was to make it more difficult to use captured gun-sights. We have still a few copies of a war-published conversion table, which gives all these freak divisions in terms of sexagesimal units, and which was produced for the edification of those who used captured material.

An article on *The Conduct of French Railways in War* is historical in character. The main conclusion drawn is that France lacked the one central railway authority which is essential to an efficient concentration of effort. At the outset no measures had been foreseen for the provisioning of large centres (*e.g.*, the milk supply of Paris).

The difficulties of organizing additional dock facilities for the carrying away of the enormously increased imports at the Channel ports (and later Atlantic ports), of railing the American troops across France, and of feeding Italy with coal, are dealt with. (Italy took 15,000 tons of coal daily !)

Of 357,000 railway employees, 29,000 were lost on mobilization, and 13,000 were left in the German-occupied areas. Another 19,000 were taken for other military duties just before the battle of the Marne.

About 45,000 wagons were lost to the French in the occupied areas, but some 8,000 replaced by rolling-stock from Belgium, etc. The loss of the big repair shops in territory occupied by the Germans made it difficult to keep rolling-stock in proper order.

The activities of French Army railway units are discussed briefly. Demolitions on the eastern frontier were well carried out, but as no French railway units were present on the northern, little or none were carried out.

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Major Klie has, in the November and December numbers, the first two parts of *A History of the Construction of F(eld) K(anone) 16 and L(eichte) F(eld) H(aubitzer) 16*. Most of us will remember their appearance on the western front. The German field-gun 96n/A pattern with an M.V. of 465 m/secs. could not get the necessary elevation for A.A. work. On the other hand, the light Howitzer 98/09 pattern had too little M.V. A compromise, effected by mounting the field-gun on the howitzer carriage, was so successful in increasing range that it was introduced for normal use and seldom available for anti-aircraft purposes. Meanwhile, experiment was continued in designing a new field-gun with increased M.V. The first step was to lengthen the barrel, but the results so obtained were poor until captured Russian ammunition was used: the M.V. was increased in this way to 540 m/sec. but involved a strain on the gun which was considered dangerous.

The next step was to lengthen the loading chamber, and to turn from fixed ammunition to separate cartridge and projectile—the latter of the cigar (stream line) shape which led to its designation (*C–Geschoss*). It was hoped to get 6,000 m/secs. M.V. and a range of 10,000 metres. Actually an M.V. of 547 m/secs. and a range of 9,000 m. was secured.

The comparative merits of an increasing and a constant twist in rifling were settled experimentally in favour of the latter—but field trials were not thorough enough. The gun was introduced, and then it was found that the increased angular velocity of the shell itself put the time fuzes in use practically out of action. Three charges had been contemplated: the lowest for short-range high-angle fire, the normal for everyday use in ordinary circumstances, and the highest for long range.

Difficulty of manufacture prevented the manufacture of the lowest and the fuze trouble interfered with the highest. The normal charge gave an M.V. of 416 m/sec.

The light field howitzer 98/09 had been considered a satisfactory weapon, but there were repeated demands from the earliest days of the war for increased range. The first experiment on these lines was the conversion of captured Russian 12 cm. howitzers. The long barrels of these converted weapons led to their being known as Howitzer guns, They were heavy, but gave an M.V. of 461 m/secs., and a range of 9,200 metres, and proved their value on the Russian front.

*A Balloon Theodolite.*—A description is given in the November number of an interesting model of a theodolite for recording the path of a small and free balloon. Observation on such balloons plays an important part in meteorological field-work. The balloon is designed to rise at a constant speed. Its vertical rate being constant, the horizontal rate of travel becomes a measure of the wind velocity at different heights. The model in question, a Hahn-Goerz, records position automatically on a table which drops vertically downwards from the theodolite at a constant rate. The "puncher" travels with the theodolite in azimuth and elevation, and a record of the path of flight is thus obtained. The duty of the observer is simply to set his automatic plotting going at a time when he has the balloon on the cross-hairs and to follow the path of flight as accurately as he can; the instrument does the rest.

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There is an unsigned article on *The Present Stage of Chemical Warfare*. The author had his tongue in his cheek, and he makes his point to some extent. He starts by accusing the Spartans of originating gas warfare in 400 or so B.C., and shows wherein he thinks that, progressively, Greeks and Romans, Saracens, Dutch, English, Russians, Americans, Japanese and French have shown partiality for it.

From that point he goes to the Hague Conference, jumps the war and gets to Versailles and lastly to the Washington Conference. Then he quotes from French, English, American and Belgium regulations, manuals and articles, and mentions activity in Italy, Spain, Poland, Switzerland, and the Scandinavian countries. He ends off by saying, "These foreign opinions and facts speak for themselves. They point a moral to the Washington Conference, and nothing need be added." The situation does not, indeed, seem to be very clear.

A short article on *Battery Board Equipment of To-day* is interesting because it shows that German gunners are content with their war-time models. The board seems to be sector-shaped with metal arcs and radial arms. The scales given on these arms are at scales of 1/20000, 1/25000 and 1/21000 (for western front, home and eastern front respectively). The socket, the paper arcs for O.P.'s and fittings generally, seem to be of the pattern which was so familiar to us in the war, and no doubt have the same good finish (with bits of cork for drawing-pins, pockets for oddments, etc.).

Two books of considerable apparent interest are reviewed in the December number.

(*a*) *Innere Ballistik*, by A. Schweickert. Barth. Leipzig. 1923. This book deals with pressures in the bore, and with various propellants.

(*b*) *Die Fernrohre und Entfernungsmesser*, by A. König, an official belonging to *Zeisswerk*. Julius Springer. Berlin. 1923. This book deals with the theory, manufacture and use of optical instruments.

H.St.J.L.W.

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*MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN*

*November–December.*

Dr. Lothar Rendulic began an article on the psychology of discipline in the September–October number, and continues it in the number under review. He is not very interesting on the relation of officer to high command, of the rank and file to their leaders, or of authority to subordinate. We have all heard it before, in much shorter compass, and with fewer hairs split. He is interesting when he talks of the bad times of the French Army in 1917 and of the events which led up to Caporetto. His heroes, Pétain and Clemenceau in France, Orlando in Italy, are those who protected the army first, and the nation second, against the doubts and fears of weaker brethren. He quotes Cadorna as writing to his government: "The internal political situation always exerts a decisive and immediate influence on the spirit of the troops in

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war, and particularly does this apply to modern war." But it is contended that the spirit of the troops must be kept undefiled not only by propaganda, and the weariness and faintness of heart of the nation at large, but must also be saved from the reaction to extravagant claims and statements by the staff. The Italian claims to decisive victories in the Carso are quoted as having had the worst possible influence on the men who fought there. The author might have drawn equally valuable inferences from the events of 1918, but refrains from doing so.

Ludwig Pengoo continues the story of the fight for Col di Lana. The Dolomite front of 100 km. was held at first by 6½ battalions—but no Italian attack developed for a month after the declaration of war. Two Bavarian battalions were on this front at the time and a German officer actually commanded a section of the defence, although war was not declared between Germany and Italy till the end of August, 1916. The garrison of the Col di Lana sector in July was about 1½ battalions, made up of companies of different regiments, with 41 guns. Numerous small attacks developed and in August the Col di Lana was occupied by the Italians, but a counter-attack drove them out.

In October German troops were withdrawn from the sector and after a series of attacks the Col di Lana position was occupied, but left the actual summit in Austrian hands. In fact, it was not before a mine had been driven and exploded under it that it was finally taken on the 18th April, 1916. The Italian position was gradually extended until May and from that time on a modified peace reigned in this sector till the Italian retreat of 1917. The article is a long one and must be studied with a map.

An article, continued from the last number, on aerial tramways is full of computations, tables and formulæ. It was written for inclusion in a book entitled *Technik im Weltkriege* and embodies a lot of useful information.

A translation of an article on our artillery in Italy, by Major Rolleston, R.F.A., which appeared in the July, 1921, *Journal of the Royal Artillery*, is included.

H.St.J.L.W.

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## *THE MILITARY ENGINEER.*

### *November–December*, 1923.

*Work of the Signal Corps.*—A brief history of this Corps from its foundation in 1880. Its policy has always been to co-operate with commercial and public activities. In its early days it founded a meteorological service, which has since developed into the U.S. Weather Bureau. During the war, the Corps expanded from 2,000 to 50,000 and, in addition to its normal work, took charge of the Meteorological Service, the Pigeon Service and the Photographic Service; photographic work involved the preparation of a complete record of the war by camera and cinema.

*Topographical Survey from the Air.*—An interesting account of recent development in this field. Major Bagley, a joint-author, is the inventor of a four-chambered camera, which takes four photographs simultaneously, thus covering a wide field. The centre photograph is

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horizontal, the other three at an angle of 35° with the horizontal. The latter are corrected for distortion by means of a transformer, but the photographs still require to be assembled on triangulated points.

*Air plane versus battleship.*—Major General Patrick, Chief of Air Service, describes recent experiments on the sinking of two obsolete battleships by aeroplane bombs. He considers that anti-aircraft guns will not serve to protect ships and that the Navy must rely on its own aircraft to counter that of the enemy.

*January–February*, 1924.

*Relation of Class Record to Success.*—This article should be of personal interest to many officers of the Corps. The author, an Engineer officer, sets out to establish a relationship between success as a student at the West Point Academy and distinction in after-life. He has had at his disposal the records of over four thousand cadets. For his statistics, the relative success of a cadet is measured by his position on the passing-out list, whilst the standard of distinction in after-life is taken as the attainment of the rank of Brigadier-General or higher. The results, which are shown graphically, are remarkable examples of the law of averages. It is clearly shown that the higher a cadet passes out the greater his expectation of success. Curiously enough, an athlete has the same expectation of success, and no more, than any other individual.

*Machine-Guns.*—This is one of the last of a series of articles on the characteristics of the various branches of the service. Major-General Farnsworth reviews the machine-gun tactics employed by the various combatants in the Great War and explains how present-day American tactics have been evolved from these, combined with their own war experience. The machine-gun in use to-day is a heavy Browning. The fourth company of each battalion is a machine-gun company of eight guns organized into two platoons. The principles of employment in attack and defence are set out in detail and appear to be in close accord with our own.

*The Training Problem of the Engineer.*—Is evidently a subject of much controversy. The author, a Colonel of Engineers, deals principally with the training of the officer. He considers that the only Engineer units to be maintained in peace should be combat troops, as opposed to specialist troops. No specialist officers are required in peace; they can be rapidly obtained in war.

The Corps of Engineers is a military organization; hence the peace training of an officer should be directed to developing his powers of leadership and command, at the same time affording him opportunities for handling men and materials in the field. Too much theory is to be avoided.

Facilities for such training exist in Engineer units and on harbour and river work. On such work, the young officer should be given a definite job and a definite responsibility. The author outlines a proposed training programme divided into two periods, the first period covering seven years, during which the officer will be available for no duty except as a means of training. It comprises two years as a junior officer with a company on first commission, one year at the Engineer School, two

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years on civil work and two years with troops as a company commander, irrespective of rank.

The second period covers five years, two of which will be in an Engineer District in charge of constructional work, the remaining three being spent on military duty. Thereafter the balance between civil and military duty should be maintained as far as possible.

The article is followed by criticism by several Senior Engineer officers and many points of interest are brought out.

R.I.M.

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### *THE COAST ARTILLERY JOURNAL.*

THE *Coast Artillery Journal* prints an interesting article by a Medical Officer of the U.S.A. Army to prove that chemical warfare, contrary to public feeling, is not more inhuman than gunfire. The author was Consultant in Gas to the IV U.S. Army Corps and President Physician-in-Chief to the large gas hospital at Toul.

As the result of poison-gas warfare the vast majority of people visualize large groups of men struggling in torment, gasping, choking and finally dying in acute agony. This picture, once more or less true, is now quite erroneous and produces quite an incorrect propaganda. It was taken from the early accounts of the chlorine gas attacks on our own Army and on the Russians of the Eastern front, but in those days the troops were surprised and defenceless.

Quickly the gas mask, at first quite a flimsy makeshift, sprang into being and gas discipline was learnt in the primeval school of self-preservation. Chlorine and phosgene, which act through the respiration organs, soon lost their efficiency and that form of attack was beaten by the defence, as always happens in the end.

The only unprotected portion of the human body was then the skin, and so mustard gas was produced, not nearly as deadly as its predecessors, but much more effective in producing casualties. The former are only effective when highly concentrated and have the disadvantage of being quickly disseminated in the air. As the author explains, "You cannot chloroform a man in the open unless you hold him down and shut out the air."

He argues quite validly that it is strategically more important to put 2000 men permanently out of action than to kill fifteen or twenty outright. Mustard gas is originated from a heavy oil projected in some form of explosive shell. The ground can be saturated with the liquid, which volatilizes with great difficulty and consequently the danger of the attack lasts for days. The resultant gas acts as a strong irritant on exposed parts of the skin and the patient is really burned with acid and not choked, as inhalation is quite unnecessary. Superficial burns heal in a few days, deep-seated burns take a long time, but are not very painful. The burn leaves few, if any, pathological after-effects. The picture described in the second paragraph has therefore been vastly modified; in place of the hundreds of coughing, choking and torn victims gasping for their lives, are seen men cold from exposure and want of sleep, truly, but quiet and occasionally laughing. Casualties

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certainly, but not suffering much or likely to be permanently disabled or even scarred. The death-rate calculated by the author was 1·98 per cent. of admission.

His conclusions appear to be that chemical warfare put more men out of action with less hurt to the individual than weapons of any other branch of the Service. He deduces that, as long as attacks on defenceless civil populations of cities and towns are rigidly outlawed, chemical warfare is less inhuman than any other battle method at present known.

D. M. F. HOYSTED, *Lieut.-Colonel, R.E.*

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*VOINA I MIR.*

No. 7.—This number starts with an obituary notice to Professor Kelchevsky, the editor, who died in Berlin on April 1st.

An article by Capt. Gorshin discusses the French provisional infantry regulations of February 1st, 1920. He considers that the group organization, with its varied armament, is unsuitable for open warfare and is the result of deductions based on position warfare only, and that the tendency towards an immobile system of defence is a tacit admission of the weakening morale of the French infantry.

Professor Kelchevsky, in an interesting article, summarizes the results of the Great War and states his ideas on the form the next great war will take. Owing to the largely increased importance of material resources, the destruction of the industrial centres of a warring country will be sufficient to insure its defeat. The future war will start with aerial battles, the victors of which will be in a position to spread destruction over the areas in which the enemy armies are mobilizing. After refilling from the numerous stores which would be distributed along the frontier, the aerial fleets would then turn to the destruction of the great industrial centres, after which harbours and naval bases would be attacked. The logical outcome of these possibilities will be the defence against aerial attack of all great industrial centres by means of anti-aircraft armament and aerial nets.

If, however, the initial aerial battles are indecisive war will be carried on by land and sea. Armies will be mobilized under the cover of a strategic screen and an extended reconnaissance will be carried out. A country which has lost its faith in cavalry will carry out the reconnaissance by means of tanks and armoured cars supplemented by small detachments of cavalry and by infantry conveyed by mechanical transport, whereas the country which still believes in the strength of the human spirit will employ cavalry on a larger scale than hitherto, well-provided with mechanical armament. Owing to the enormous frontage taken up by modern armies, it is unlikely that any country will be in a position to construct a sufficient supply of machines to adopt the first method.

It is possible that a recognition of the fact that a complete aerial conquest would entail irremediable damage to the country subdued may lead to the adoption of a " strategy of exhaustion " in place of a " strategy of annihilation " by the warring powers, and the war might

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then take on a passive form (as in the World War) in which, for the sake of economy, gas in various forms would probably be used on a large scale.

An article by P. Zaliessky gives examples of the use of cavalry from earliest times and discusses the probable manner of its employment in wars of the future.

Lieut.-General Borisov, of the General Staff, in an article entitled "Fortresses of the Future," describes the part played in the World War by certain fortresses on the Russian Western front. For instance, the defeat inflicted by the Russians on Ludendorff in September, 1914, when he was trying to seize the line of the Vistula was largely due to the fortifications at Novo Georgievsk, Warsaw and Ivangorod, though the works at the two latter places had been destroyed some time before the war and had been only half restored. In August, 1915, the fortress of Novo Georgievsk was isolated and invested by the Germans; it fell in ten days. It was the only Russian fortress to put up a defence and it fell through the weakness of the commanders, poor spirit of the troops, lack of artillery and material, and weakness of the defences. Kovno was also isolated, but surrendered at once.

The author arrives at the following deductions regarding Russian fortresses:—

1. The extent of Russian territory excludes the useful action of strategical fortresses.
2. The flatness of the ground necessitates the use of tactical fortresses, as centres of resistance on a wide level theatre of war.
3. Tactical fortresses on the frontier would assist a plan for invading the enemy's country.
4. Fortresses would be useful in connection with bridges, defiles and forests.

By strategical fortresses are meant those which can be held after complete isolation, whereas tactical fortresses are held only so long as they are required for purposes of manœuvre.

The "Arming of Infantry" is a series of extracts (illustrated) from an article by Colonel Morcalli in the *Rivista di Artigleria e Genio*, with an introduction by Professor Kelchevsky.

In an article called "Artillery Intelligence", Capt. Ritter discusses and transcribes an article by Lieut.-Colonel Brood which appeared in the Journal of the Royal Artillery.

*The Crossing of the River Nethe at Lierre* is a description, by Capt. Ritter, of the passage of the Nethe south of Antwerp by the Germans in October, 1914. The outlying forts of Antwerp south of the Nethe had all fallen to the Germans on October 3rd. The country bordering the river had been inundated to a width of 400 metres and all the bridges had been destroyed. The water was so shallow that pontoons could not be used. The Belgians were entrenched on the north bank and fired at anyone who showed his head, whilst the southern bank was under heavy fire from the fortress guns. A general attack on the whole front would have been attended with heavy loss; it was therefore decided to attack Lierre, which was not only completely surrounded by branches

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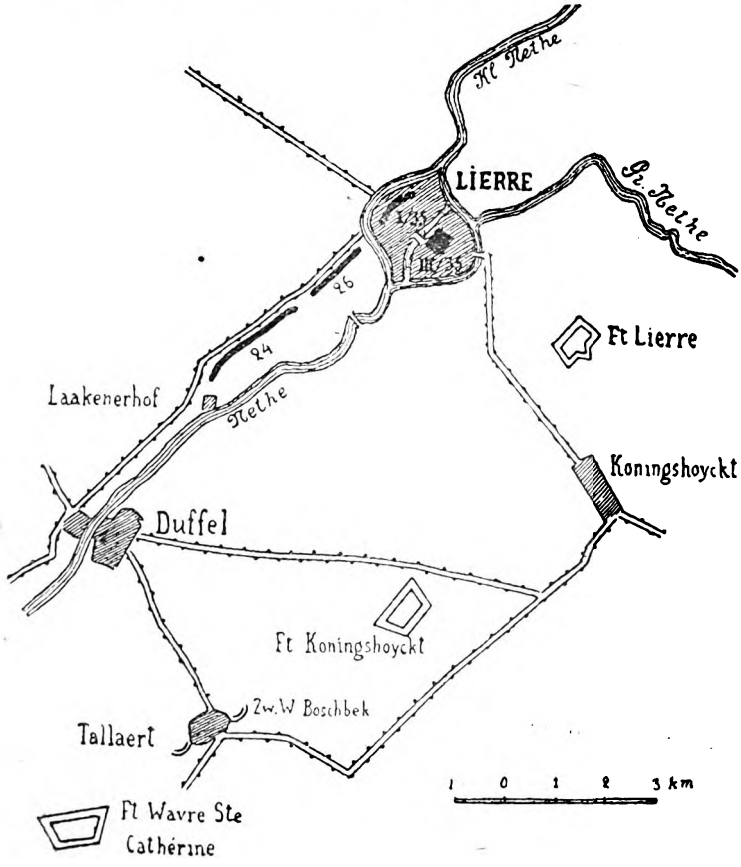
of the Nethe but had a branch running through the middle of it. There were, therefore, three streams to be crossed. The attack was started at 6 p.m. on October 4th by the 1st and 3rd Battalions of the 35th Reserve Infantry Regiment of the 6th Reserve Division and one Reserve Sapper Battalion. Under cover of fire from the infantry, the sappers made arrangements for crossing the first branch, and 25 minutes later a large body of infantry had crossed. There was no bridge over the second stream, but the sappers managed to arrange a crossing, in spite of heavy fire from the houses, and by the evening the 3rd Battalion had occupied the market square whilst the 1st Battalion had entrenched itself between the second and third branches. Unfortunately, the author gives no details of the construction of these bridges. As night fell, the troops who were isolated from the main force on the south bank of the Nethe were subjected to heavy fire from the barricades and houses, and were unable to advance further. The fearless sappers, however, repaired a partially destroyed bridge over the first branch of the Nethe; some guns of the 6th Reserve Regiment immediately crossed, unlimbered in the market square and opened fire. Advance still seemed impossible as long as the western and north-western edges of Lierre were flanked by fire from the Belgian positions north of the Nethe and west of the town. It was therefore decided to cross the Nethe west of the town.

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The crossing was carried out by the 26th Reserve Regiment and the remaining brigade (20th and 24th Regiments) of the 6th Reserve Division on the night of the 4th–5th. In the morning this force was in an unpleasant situation, with the river 200–600 metres in rear crossed by one half-destroyed bridge on their extreme right flank. A weak counter-attack by the Belgians was repulsed, a strong one would probably have succeeded. Still the Germans were unable to advance; they were exposed to heavy artillery fire and suffered from want of food and water; fresh supplies of ammunition could not be delivered.

On the night of the 5th–6th the tireless sappers made a bridge over the third branch of the Nethe near the western edge of Lierre. At dawn three batteries were able to cross and rendered the necessary assistance to the infantry which had been held up on the north bank to the west of the town. The Belgians thereupon withdrew to a position further north. About mid-day on October 6th the 1st Battalion of the 35th Regiment crossed the third branch and the object was attained.

Points worthy of notice in this action are: the uselessness of a passive defence even when assisted by a natural obstacle such as a river; the important part played by engineer troops.

Capt. Ritter refers to the Belgians as the "enemy" throughout this article, which is not, apparently, a translation from the German; it seems rather strange that such a term should be used in a Journal produced under the editorship of our late allies.

The Bibliography at the end of the Journal contains a short review of the *R.E. Journal* of December, 1922.

*No.* 8.—In the eighth number of this journal Captain Ritter, of the German General Staff, contributes a long and interesting article called "A Comparison of the Strategy of Napoleon and Schlieffen." The gist of it is that Napoleon recognized that strategy is an art and not an exact science. He refused to be bound by systems. This contempt for hard-and-fast rules is shown by the absence of Regulations in the French Army of his time, the latest being those of 1791. With a few lightning blows he shattered the false conceptions of the art of war of the post-Frederick period, the essence of which consisted in forcing the enemy to retire by skilful manœuvre with as little bloodshed as possible. He never approached any situation with preconceived ideas, but made a special study of each situation and took special means to meet it. The diversity of his resource, his versatility, his "many-sidedness," are well shown in the campaigns of Jena, Grossgörschen, Ulm and Regensburg; to quote his own words: "Fixed and unchanging rules do not exist; everything depends on the capabilities of the general, the quality of his troops, the time of year and a thousand other things which go to prove that no two cases are ever alike."

Turning to Count Schlieffen, the writer maintains that he possessed the same qualities as Napoleon, as did also his great predecessor Moltke; there was a widespread idea that he was an exclusive devotee of the strategy of envelopment, but this was erroneous. He had certainly advocated a policy of envelopment in several works, notably "Krieg in der Gegenwart" and "Cannæ," but this was because he had realized that in a war where large numbers were employed success could only be

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gained by action against the flanks. The logical outcome of this idea was that the enveloping movement should begin at the time of deployment, *i.e.*, before the armies had left their own territory. He had made a close study of the Russo-Japanese war and his opinions had been deduced therefrom. He wrote: "Mass formations lead to insufficiently strong frontal blows which, inflicted one after another, become weaker and weaker, producing scarcely any result. . . . Owing to this the modern battle becomes a struggle for the flanks in a greater degree than in former times. In this fight for the flanks the victor will be he who has his reserves, not in rear of his centre, but near the decisive wing. These reserves cannot be directed to the point which the leader in a battle extending over many square miles has, with his eagle eye, selected as the decisive one . . . they must be sent there at the very beginning of the battle."

S. Dobrorolski, in an article entitled "Defence in Strategy and Tactics," states that the strategy of a country depends on its geographical position. The strategy of Russia, with its vast territory, should be a defensive one. A true defensive strategy does not consist in a "stabilized" defence in lines of trenches, such as occurred in the World War, but should admit of every advantage being taken of depth of territory for the manœuvring of armies. Defensive strategy was practised with success by Russia in 1707–08, when Charles XII. was drawn on to defeat at Poltava, and in 1812 against Napoleon. An initial advance, in which serious encounters are avoided, is required in order to allow time for preparation in the case of a country like Russia. In 1914 the Russian advance met with disaster and the retreat was followed by a demoralizing trench warfare. In countries where room for manœuvre is lacking, recourse must be had to fortifications, the value of which, though discredited in some opinions by the rapid fall of Antwerp, Liége and other fortresses, has been fully established by the examples of Verdun, Przemysl, Ossovets and the obsolete Ivangorod. Strategic defence implies mobility and the full use of territory for manœuvre, immobility must be avoided at all costs. Dealing with defence in tactics, the author lays stress on the necessity for depth and the futility of a "wooden" defence in which lines of trenches are crammed with troops determined not to yield an inch of ground. He emphasizes the need for elasticity, that is, the ability to exhaust the attack by recoil and then to advance in counter-attack, which is the soul of defence.

General Zalesski continues his article on cavalry, dealing with their organization, employment, discipline and instruction. He pays a compliment to the horse-mastership and organization of the British cavalry.

In "Artillery at the Attack of Fortified Positions," Captain Ritter describes the gradual improvement in artillery tactics of the German Army during the Great War. At first, in 1914, infantry attacks were carried out with little regard to artillery co-operation. Trench warfare necessitated close co-operation between infantry and guns, and careful preparation before the attack, which, however, militated against surprise. The problem arose as to how adequate artillery preparation could be given without violating the principle of unexpectedness and suddenness,

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The author explains at considerable length and in great detail how this end was attained in the German attack on the Anglo-French position on the Chemin des Dames on May 27th, 1918.

A. Shershevski contributes an article on giant aeroplanes. He explains that the limitations to size, as enunciated by Professor Lanchester, have proved fallacious, whilst Professor Rorbach's investigations have led to more reliable deductions. He discusses the nature of material, type of engine, and shape, most suitable for large aeroplanes. He describes several examples either projected or actually constructed; amongst the latter a *hydroavion* designed by L. Caproni in the form of a triple tandem triplane with eight 400-h.p. engines, and capable of carrying 100 passengers. It crashed at its first flight. The article is well illustrated.

*No.* 9.—In this, the ninth number, the new Russian orthography has been adopted whereby two vowels are replaced by two commoner ones of the same value.

In an article entitled "Corps or Division," S. Dobrorolski discusses the desirability of a permanent Corps formation in times of peace, as against the improvisation of Corps on the outbreak of war. He writes with considerable feeling, for during the war the Division he commanded served at various times in fourteen different Corps, in twelve different Armies, and on all four Russian fronts, so he fully realizes the disadvantages of the temporary allotment of Divisions to Corps.

The Corps formation was first adopted in the peace organization of the Russian Army in 1810, but was abandoned in 1862 and again adopted in 1879, it was therefore in existence at the beginning of the World War. Owing to the fact that the Russian Army, unlike the German, had no reserve Corps formations, on the outbreak of war all their peace Corps had to be reorganized to include Reserve Divisions, a measure which largely detracted from the advantages of the peace organization.

The author attributes the numerous tactical successes of the Germans on all fronts to their permanent Corps system, and gives an example in illustration. He considers that, under the conditions of modern warfare, a permanent Corps organization is more desirable than heretofore.

A.H.B.

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*VOIENSKO-TECHNITSKI ZPRAVI.*

WE have received from the Minister of National Defence of the Czecho-Slovak Republic the first number of their *Military Technique Review*, which is to be published bi-monthly and will treat of technical questions concerning arms and military services. The number contains articles on the effects of artillery projectiles and the construction of dug-outs, military survey, light bridging, etc.

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*UNITED EMPIRE.*

The February number of *United Empire* contains a short account, with photographs, of Australia's Military College at Duntroon, which is to be congratulated at having recently survived a serious attempt to retrench it out of existence.

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# *THE OPERATIONS OF THE 1st DIVISION ON THE BELGIAN COAST IN 1917.*

*By* Bt. Colonel W. G. S. DOBBIE, C.M.G., D.S.O., R.E.

*The General Situation.*—The year 1917 was a very busy one, both for the British Army and Navy. The failure of the French attack in Champagne in the spring, and the serious effect on the French Army of that failure, imposed on the British Army the formidable task of keeping the whole of the German Forces on the Western Front so busily employed that the French Army should be given the opportunity to recover without interference from the enemy. This obligation, great as it was, was accepted and fully met, though at the cost of severe and continuous fighting from April to November. Major operations succeeded one another with startling rapidity; attack followed attack at Arras, Messines, Ypres and Cambrai, with the result that all the German Divisions were drawn into the fight one after the other, and the whole of the energies of the German higher command were directed to stopping the holes punched in their lines by the successive British attacks. The French were thus given the breathing space they needed so sorely, and were able to reorganize their armies without interference. The Italians also reaped the benefit of the British activity, since it prevented the Germans from detaching more than about six Divisions to assist the Austrians in their attack on the Italians in the autumn. If the number of German Divisions in Italy had been doubled, it is not pleasant to contemplate what would have been the result on the course of the war.

*The Naval Situation.*—The British Navy, meanwhile, was also faced with a very difficult task. The German submarine campaign was becoming more and more difficult to deal with, and was taking a continuous and ever-increasing toll of the shipping on which we depended for our supplies of food and the sinews of war. Our ships were being sunk considerably faster than we could build, and it was only a matter of time before a situation of the utmost gravity would arise.

The German submarines were greatly helped in their operations by the proximity of their bases on the Belgian coast, and it was the opinion of the British Admiralty that the situation could not be materially eased until these bases were neutralized.

*The Problem Stated.*—This result could be achieved by operations either from the sea, the air, or the land. As regards an attack

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from the sea, the strength of the German Coastal Batteries made this operation hazardous in the extreme. The whole of the Belgian coast in enemy occupation was protected by guns of the largest calibre, and in great numbers, covered by the strongest and most up-to-date defences, and the shooting of these guns, as our ships knew to their cost, was unpleasantly accurate and effective. An attack from the sea, therefore, was not an operation to be lightly undertaken. An attack from the air was also not likely to achieve the success desired. The German anti-aircraft defences were extraordinarily complete, and most efficiently organized, and in the nature of things no *decisive* result could be obtained from any air operations which were at that time possible. It was therefore decided that an attempt should be made to approach these bases from the land side, and this provided a special objective for the Army.

It was considered that the desired result would be sufficiently achieved if the land forces could gain enough ground on the coast so that heavy railway guns and howitzers could be mounted within effective range of the submarine base of Zeebrugge, and thus keep it under more or less continuous fire. By this means it was anticipated that the activities of the submarines would be so much hampered that the value of the port to the enemy would be almost altogether discounted. For this reason the northern operations of the British Armies in 1917 were invested with especial importance, in that they enabled the British Army to fulfil its two functions, *i.e.*, assisting the French by occupying the attention of the Germans and assisting the British Navy by threatening Zeebrugge.

*The Land Operations in* 1917.—The British attacks commenced at Arras, and were continued later in the Ypres salient, the battle of Messines being in the nature of a preliminary operation to the more serious undertaking further north. One of the objects of the third battle of Ypres was the neutralization of Zeebrugge. With this end in view it was intended that the Fifth Army should push north-eastwards from Ypres in the direction of Staden, and that when that point had been reached a further movement in a N.E. direction should be carried out by the Fifth Army in conjunction with a movement on Ostend by a British Force in the coastal sector.

*The Coastal Sector.*—Up to the beginning of June, 1917, the Coastal Sector had been held by a French Corps, with the Belgian Army on its right, but in order to prepare for the operation above outlined it was necessary for British Troops to relieve the French on the coast. This was done by the dispatch of the XV British Corps (1st and 32nd Divisions), which relieved the French in the latter half of June, the French being withdrawn to the French zone proper. The 1st Division occupied the sector on the coast, and the 32nd Division the sector on its right which included the town of Nieuport.

The situation in the 1st Division sector at the time was roughly

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as follows. The line ran some 600 yds. or 800 yds. east of the River Yser, which was an extremely formidable obstacle, swift-flowing, deep, wide and tidal. When the British relieved the French there were only three floating bridges in the 1st Division sector, and these three bridges were close together near the mouth of the river. No preparations had been made to throw any other bridges, and the insecurity of the two battalions occupying the defences east of the river was obvious. During the period of the French occupation a policy of "live and let live" had apparently been in force, and although the British were assured that the sector was delightfully quiet, it was obvious that our existence east of the river for the moment depended on sufferance. The defences east of the river also were quite unable to withstand a bombardment even of moderate severity, and altogether the situation was far from satisfactory. However, steps were taken immediately to improve matters. Stores were collected for the construction of additional bridges which could be thrown at short notice in an emergency. Dug-outs were begun, and the defences improved generally. Raids were initiated in order to obtain identifications. Additional artillery was installed and the air defences put on a more satisfactory footing. But all this took time, and it was fully realized that until these improvements had been completed the security of our advanced positions depended to a great extent on the goodwill of the enemy, who would be sure to realize that the relief of the French by the British boded no good for him. It was, however, decided that it was necessary to accept the risk for reasons which are set forth below.

*The General Plan of Advance by XV Corps.*—As has been already explained, the British Troops in the coastal sector were to co-operate with the Fifth Army when the latter reached Staden. It was thought that by that time many of the German Reserves on the coast would have become involved in the fighting further south, and the advance along the coast would be thereby facilitated. This advance, in any case, was likely to be a difficult operation, as the frontage on which the advance could be made was extremely narrow, and the low-lying and water-logged country on the right made manœuvre a matter of the greatest difficulty. It was, therefore, important that the bridgehead east of the Yser should be maintained, as the loss of it would render an advance infinitely more difficult, since it would involve the forcing of the passage of the river. It was, moreover, decided that the advance along the coast should be synchronized with an attack on the enemy's communications by a Division moving round the enemy's right flank and landing in rear of his landward defences. The 1st Division was selected for this operation.

*The 1st Division in the Coastal Sector.*—The 1st Division was put into the line in the coastal sector, presumably because no other

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Division was at the moment available, and perhaps, also, in order that it might become acquainted with the lie of the land on the coast in view of its subsequent rôle. But this rôle demanded a lot of special training of various natures, and in order that it might be ready to carry out its task during the first half of August, it was decided to keep it in the line only until the 16th July, and then withdraw it and concentrate it in a special camp west of Dunkirk, where the training could be carried out without interruption. The significance of the relief of the French by the British in the coastal sector had not been lost on the Germans. It was obvious to them that it portended the initiation of some active measures on our part. It is doubtful whether they realized at this time the full significance of the change, but at any rate they very wisely decided to make our expected operations as difficult as possible by seizing the bridgehead on the right bank of the Yser. This they proceeded to do on the 10th July at a time when our improvements to the defensive system were still incomplete, and before our full allotment of heavy guns had arrived. The German guns commenced a bombardment about 9 a.m. of the area occupied by the two Battalions of the 1st Division east of the river, and of the bridges near the mouth of the river. These latter were soon destroyed, and all attempts to repair them proved fruitless. The bombardment increased in intensity until it exceeded anything the writer encountered at any other period of the war. The weak defences were destroyed, rifles, Lewis guns and Vickers guns were rendered useless by the all-pervading sand, and when, at length, the German Infantry advanced, they were able to overcome without difficulty the remaining opposition. The two Battalions concerned, the 2nd K.R.R.C. and the 2nd Northants, were almost completely destroyed—only about 100 men of the two regiments altogether escaping. The situation had to be accepted, as no counter-attack was possible with the resources available—nor, indeed, was it advisable to re-occupy the right bank of the river (even if it had been possible), as there was nothing to prevent the same thing happening again until the whole of our material resources on the coast had been very largely increased. *Photo* No. 1 shows the area occupied by the left Battalion (2nd K.R.R.C.). It was taken some days after this attack. The wreckage of the bridges can be seen in the river.

*Withdrawal of the 1st Division for Special Training.*—The only advantage of the whole episode was that, when the 1st Division was withdrawn from the line six days later, according to plan, the Germans no doubt connected its relief with the severe handling experienced by the two Battalions, and did not then grasp its true reason. Meanwhile, preparations had been made for the construction of a camp for the Division on the coast near Le Clipon, about six or seven miles west of Dunkirk. A large area was carefully fenced off,

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a light-railway system was installed to facilitate the handling of stores, and an adequate water supply was arranged.

These preparations were completed by the 16th July, when the Division marched westwards after it had been relieved in the line by the 66th Division, and occupied the camp. It was fully realized that the success of the projected operations depended on absolute secrecy being maintained. Should the least whisper of the plan leak out, that success would be gravely jeopardized. Consequently the plan was told to no one until the Division was safely within the fenced camp. Elaborate precautions were then taken to prevent any leakage of information to the outside world. Those inside the camp had no intercourse whatever with those outside. Rations and stores were delivered to the camp through a system of " locks," whereby those who brought the stores did not meet those who received them. Special pickets were always on duty at the entrances to the camp, while the perimeter of the camp was constantly patrolled. All letters were dealt with by a special staff of censors at the base, and all leave was stopped. And last, but by no means least, it was explained to the troops that the success of the operations, to say nothing of the safety of themselves and their comrades' lives, depended on their loyal co-operation in keeping the projected operations completely secret. And one may say here that right well did they respond, indiscreet letters were amazingly scarce, and it is certain that if the secret did leak out, it was not through any of the troops detailed to take part in the operation. Inside the camp were only those who were going to accompany the expedition—all the rest, including all the horses of the Division, were outside. Units were thus to some extent split up, but in spite of all the inconvenience caused, the isolation of those within the camp was rigidly enforced. It was on account of this complete lack of transport within the camp that the system of light railway had to be installed to deal with the carriage of stores, water, rations, etc.

Space will not admit of a description of the R.E. work undertaken in connection with this camp by the 1st Divisional Engineers, under the direction of the C.R.E., Lieut.-Colonel C. Russell-Brown. Its extent and variety made it extremely interesting, and perhaps Colonel Russell-Brown may be inclined to write a description of it for the benefit of his brother officers in the Corps.

*The Plan of Operation.*—It is now necessary to consider the plan of operation in some detail. The task of landing a Division in rear of the enemy's landward defences was not an easy one. Many factors contributed to its difficulty. In the first place there was the enemy to be reckoned with. Ever since the early days of the war, when we had landed troops on the Belgian coast, he was nervous of his right flank. He had consequently established fixed seaward defences all along the coast and these defences were of the most

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formidable character, both in quality and quantity. These fixed defences were supplemented by mobile forces to the extent of two Naval Divisions stationed permanently on the coast. Further, the air defences were, as previously mentioned, extraordinarily complete and effective. In addition to the formidable difficulties provided by the enemy, there were those which Nature provided. The coast is absolutely straight; there are no headlands and bays to afford any cover; the sea is too shallow for large vessels to approach close to the shore—there are numerous sandbanks which are continually shifting, and the contour of the shore below high-water mark frequently changes. The tides are very strong and an on-shore breeze very soon raises an ugly sea on the beach. Such were some of the difficulties, and it now remains to indicate the way in which it was intended to solve them.

The difficulties provided by the enemy must be overcome by surprise, the surprise to cover, if possible, the *fact* of the projected landing, and at all costs the actual place and time. The methods employed to ensure surprise have already been referred to, but they were to be supplemented by other methods to blind and mislead the enemy as the time drew near.

Owing to the shallowness of the sea, the only Naval vessels which could support the attack were shallow-draft monitors. These vessels, although carrying heavy guns, had little or no protection, and a very low speed. They could not hope to compete successfully with the powerful coast defence batteries with which the coast bristled. It was therefore necessary for the security of the monitors that the movement to the landing-place should take place during the hours of darkness, which should be supplemented by smoke screens, under cover of which the monitors should withdraw when their task was done. The necessity of the smoke-screen fixed another essential condition for the success of the operation. The wind had to be on-shore, but it must not be too strong, or an ugly sea would be running on the beach, making any operation there very difficult. Then came the question of how to ensure a rapid landing of the attacking troops, as, when once the attack started and the alarm had been given, speed in landing was all-important.

This problem was solved in a most ingenious manner by Admiral Bacon, who was then in command of the Dover Patrol, and with whom the military were to co-operate in the operation. He devised a structure called a pontoon—some 600 ft. long and 30 ft. wide. The draught in front was about 1 ft. 6 in., and the draught behind about 4 ft. 6 in. Three were built, and on these were to be carried all the vehicles, guns, bicycles, etc., which were to accompany the Division, while a gangway 10 ft. wide was left down the whole length of the pontoon, in which troops could be accommodated, and by which they would reach the shore. These pontoons were each

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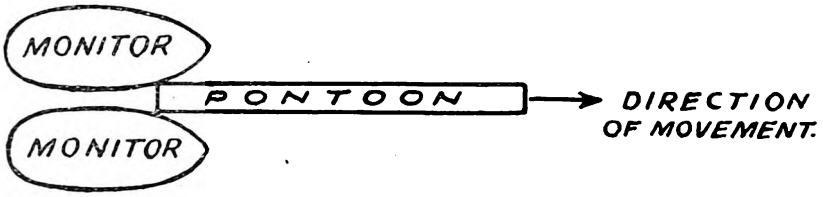
to be pushed by two monitors fastened abreast of each other against the rearward end of the pontoon, thus :—




Three of these pontoons were to be provided, together with six monitors, forming altogether three composite units, each carrying one brigade of infantry with the necessary complement of other arms.

The plan then, very generally, was for these three pontoons, together with their attendant monitors, to be pushed under cover of darkness, on a suitable date, so as to reach the selected site of the landing at a suitable time ; to run the pontoons ashore, and allow the attacking troops to rush ashore, overcome the defences, and establish themselves before the enemy could collect sufficient troops to stop them.

*The Selection of the Landing Places.*—Such was the general plan, but there were, of course, very many details which had to be thought out and arranged. It was necessary first of all to decide on the point of attack, as the detailed arrangements would naturally be somewhat affected by the points chosen for the landings. This presented a pretty problem—the further to the east that the landing was made, the greater would be the effect, in the event of success, but the greater the danger to the Division in view of its increased isolation. It was, however, important that the landing should be effected within reach of (*a*) the Raversyde Coast Batteries, and (*b*) the bulk of the landward guns covering the German line on the Yser. As regards (*a*), it was necessary to silence and destroy the German guns in the Raversyde Batteries, as, until this was done, the movements of the naval ships would be greatly hampered when once the smoke-screen was finished, and the sea, as a line of supply for the 1st Division, would be made very insecure. As regards (*b*), the destruction of these guns was necessary in the interests of the troops of the XV Corps, who were to attack along the coast. The bulk of these guns were in the neighbourhood of Westende. These various conflicting claims were taken into consideration and it was decided that one landing should take place at Middlekerke (see *Photo* 3), and the other two between that place and Westende. It was hoped that it would be possible to dispatch a flying column to deal with the Raversyde Batteries from the Middlekerke landing, and preparations were made accordingly.

*The Sea Wall.*—In the area selected for the landings the coast was protected by a concrete sea wall of formidable dimensions. The

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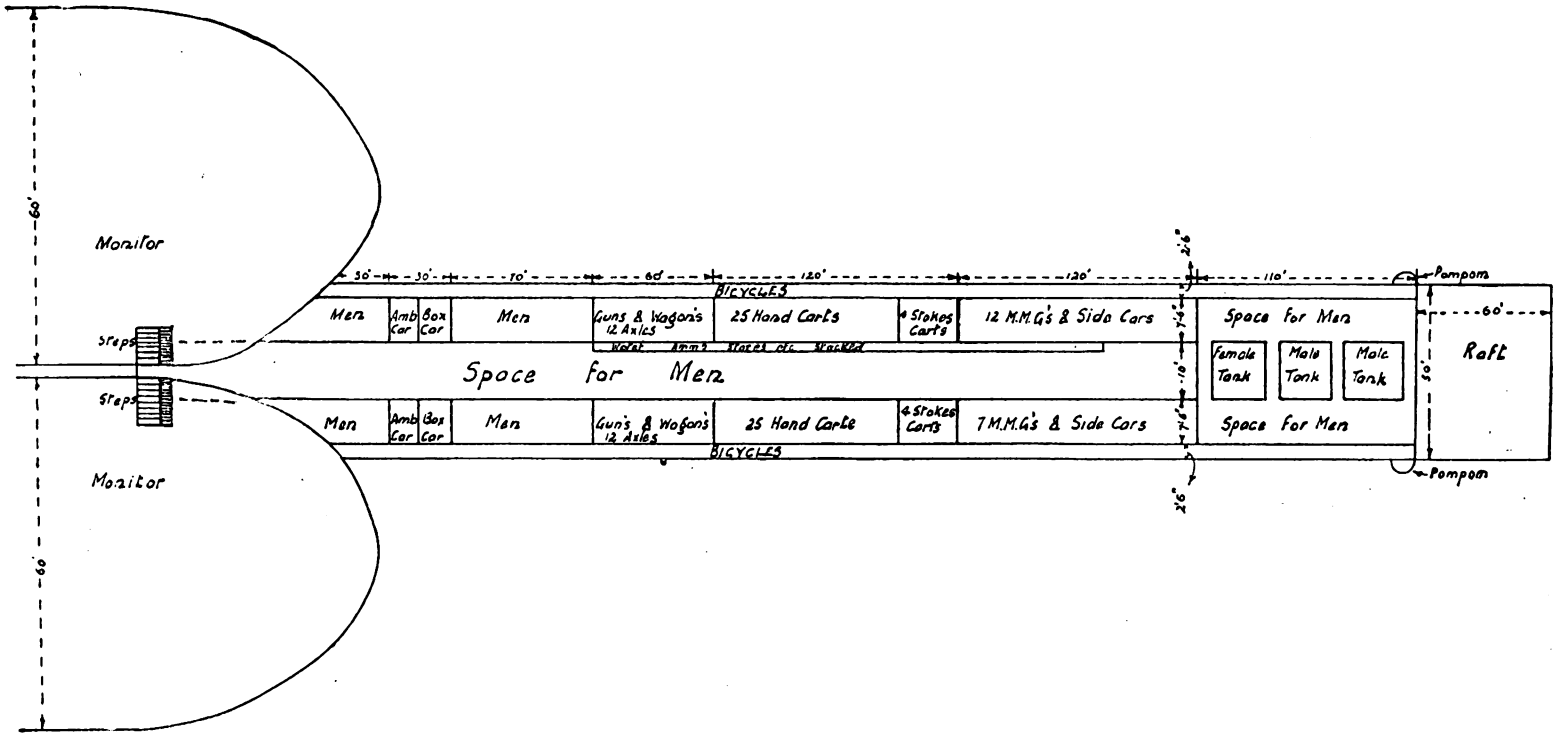
PLATE I.

(Not to Scale.)

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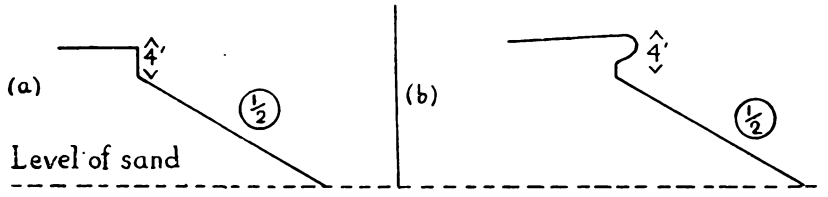
face of the wall was set at an angle of 1 in 2, and the top of the wall was some 30 ft. or more above the level of the sand. The top portion of the wall was of two different patterns. On part of the front there was a vertical rise of about 4 ft. to the level of the esplanade beyond, and at other parts there was a large overhanging coping. The two patterns were therefore as shown in the following diagrams.




The height above the level of the sand, of course, varied in different places—and was also subject to fluctuations due to weather. In certain places the sea at high tide reached the foot of the wall, but mostly there was always a strip of sand to be negotiated before reaching the wall.

This wall constituted a serious obstacle to the assaulting infantry, tanks, guns and vehicles—all of which had to surmount it. In order to find out what could be done, full-sized models of both types of wall were made both in camp at Le Clipon and at the Central Tank Workshops. Tanks were then actually tried over the obstacle, and it was found that they could surmount the type (*a*) wall without any special preparations, but that they were stopped by type (*b*). The difficulty in this latter case was overcome in an ingenious manner. A wedge-shaped erection of strong skidding was made, designed to fit more or less into the recess under the overhanging coping of the upper part of the wall. This was carried on the end of a pole which projected in front of the nose of the tank, and could be disengaged and cast loose by the crew from within the tank. The idea was that the tank should carry this erection up the wall until it came to the coping. It would then push it into position under the coping, and after the crew had cast it loose, the tank would then climb over it and so on to the top of the wall. This was actually tried over and over again on the model wall at the Tank Central Workshops with invariable success, and this method of surmounting the coping was then embodied in the scheme of operations.

The diagram on the opposite page illustrates the method above described.

The model wall in Le Clipon Camp was used for training the assaulting infantry, who were practised daily in running up it, first without, and then with, their full loads. It was most interesting to note the way they improved in this particular exercise. At first

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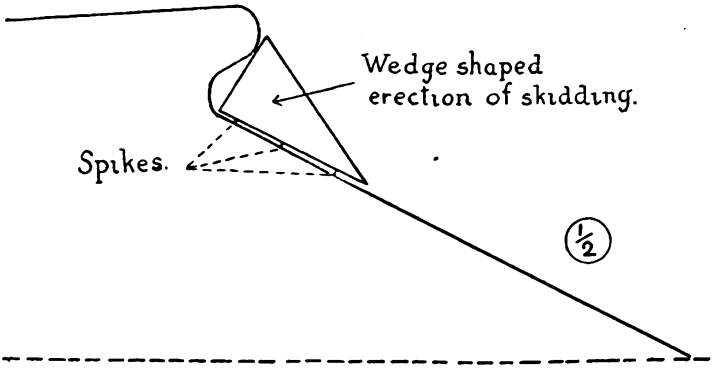
they were all at sea, and could barely stand on the face of the wall, let alone move upwards upon it. Before long the majority were absolutely at home upon it, and were able to move up and down the wall with the greatest freedom, even though carrying heavy loads, such as bicycles, ammunition, etc.

To assist the less agile men, or those carrying especially heavy or awkward burdens, it was arranged that some of the leading men should carry with them ropes fitted with a grapnel at one end. The grapnel was to be secured at the top of the wall and the rope left to hang down along the face of the wall and thus help those who needed it.




The question of getting the guns, etc., up the wall had still to be considered, and the difficulty was solved in the following manner. Of the three tanks detailed for each of the landings it was arranged that one should be a "female" tank, fitted with winding gear. This tank would follow the two male tanks, climb the wall, establish itself on top, and as soon as the local situation was suitable and the infantry had established themselves on shore, it would devote itself to the task of hauling the guns, etc., up the wall. For this purpose it carried a wooden ramp, up which the wheels of the guns would travel, and they would, in this way, be able to negotiate the cornice at the top of the wall.

So much for the sea wall and the problems it raised.

*Composition of Landing Force.*—It is now necessary to refer to the composition of the landing force. The following troops were available:—1st Division complete; 2 Cyclist Battalions; 3 Motor Machine-gun Batteries; 9 Tanks; Mechanical Vehicles as required.

In deciding on the composition of the landing force the following factors had to be considered:—

(*a*) No horses could accompany the landing force.

(*b*) The space provided by the Navy for the transport by sea of the force was strictly limited.

(*c*) The force had to be prepared to be independent of outside assistance for at least 48 hours.

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In these circumstances the following decisions were taken :—

(*a*) All the infantry (including trench mortar batteries) to be taken, but without horsed transport.

(*b*) A composite artillery man-handled battery to accompany each infantry brigade—to consist of :

4 18-pdr. guns and limbers.
2 4·5 in. howitzers and limbers.
6 ammunition wagons and limbers.

(*c*) One Field Company, with 1 company Pioneer Battalion attached, but without horsed transport, to accompany each landing.

(*d*) One motor machine-gun battery to be allotted to each landing.

(*e*) Cyclists to be divided among the landings in the following strength :—

Left Landing : 1 battalion.
Centre Landing : 1 battalion (*less* 1 company).
Right Landing : 1 company.

(*f*) A small medical detachment with two motor ambulances to each landing.

These were in addition to the medical personnel with units.

(*g*) A certain number of hand-carts to be allotted to each unit, to take the place of horsed transport left behind. These were intended to carry ammunition, grenades, tools, water, reserve supplies, etc.

(*h*) Special signal arrangements to be made. These are described later on.

(*i*) Three tanks to be carried on the fore part of each pontoon, in single file—two male tanks and one female, the latter being the rearmost of the three.

*Arrangements for the Landing Force on the Naval Ships.*—Having settled the general composition of the force, it was then necessary to ascertain the best method of disposing it on the pontoons and monitors, with a view to getting it ashore in the quickest possible time, and without confusion. It was, of course, necessary that the leading troops should establish themselves ashore as quickly as possible, as surprise was the first condition of success. It was also important that the remaining troops and impedimenta should be landed without delay, and clear the beach, as the monitors were likely to come under heavy fire as soon as the smoke-screen was dissipated. In consequence, experiments were carried out on shore in the camp at Le Clipon to ascertain how these ends could best be achieved. Full-sized plans of the monitors were marked out on the sand, with the various obstructions on the decks indicated, such as guns, ventilators, funnels, etc. By this means the available

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deck space was ascertained, and by actual trial accurate information as to the number of men which could be carried was obtained. Similarly, a model of a pontoon was marked out in camp, and packing trials for the various vehicles were practised on it, and, after much thought, the arrangement shown in *Plate* I was adopted. It was also decided that the centre gangway of the pontoon should be occupied by the troops of the two leading Battalions, arranged abreast of each other, so that as soon as the tanks had moved, the two leading Battalions could rush ashore simultaneously and extend outwards, so forming an ever-enlarging bridgehead. Practice was then given to the troops in getting ashore quickly, by actually carrying out this manœuvre over and over again from the model of the pontoon in the camp. The way in which the operation was speeded up by these practices was nothing short of marvellous. Competitions were held among the three Brigade Groups and as a result of these, the time taken to clear the pontoons and the attendant monitors was reduced to about ten minutes.

It had at one time been intended to use lorries (F.W.D.) for the haulage of guns and carrying ammunition and stores, but so much difficulty was experienced in getting these over the sand that it was decided to do without them, and to revert to man-haulage for the guns and ammunition wagons of the artillery.

*Stores to be Taken by the Landing Force.*—The question of what stores should be taken with the landing force was one that demanded very careful consideration. The space for stores was strictly limited, as were also the means of carrying them, *i.e.*, the hand-carts. It was therefore necessary to discard everything which was not vitally essential. Ammunition for rifles and M.G.s was, of course, the first requirement, as the Division, when landed, might have to hold its own against repeated counter-attacks without being able to replenish its stocks of ammunition. Another essential was water, a reserve of which had to be carried, as it was by no means certain that an adequate local supply would be forthcoming on shore. Tools, reserve supplies, sandbags, etc., had all to be considered and provided for. The tool question was, of course, especially important in the case of the field companies, and very careful discrimination had to be exercised as to what was to be taken and what left behind. Explosives also formed a very important item, as they would be required to deal with the Raversyde Batteries. Some water supply stores, *e.g.*, pumps, had also to be taken.

After deciding what could not be left behind, it was found that the number of available hand-carts was not sufficient to carry all that had to be taken. It was therefore decided that certain stores, such as reserve supplies, water and ammunition, which would not be required immediately on landing, should be stacked on the pontoons and dumped on the beach as soon as all the troops had disembarked.

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These stacks measured about 240 ft. long by 1 ft. 6 in. wide by 4 ft. 6 in. high on each pontoon.

*Information about the Landing Area.*—The next necessity was to instruct the troops as to their action on landing. To this end an elaborate model of the coast was prepared in a hut specially built for the purpose in camp. In this model every house was shown, the shape and colour being reproduced as exactly as possible. The collection of the necessary information on which to construct the model was a matter of some difficulty, but the details were gathered from many different sources, and it is believed that in the end a fairly high degree of accuracy was obtained. Some information came from direct observation, powerful telescopes being mounted at points within our lines from which the coast could be seen about Middlekerke and Westende. Other information came from photographs and picture postcards taken before the German occupation; others came from air photographs taken in many an unpleasant trip by No. 34 Squadron, R.A.F., which produced oblique photographs, taken from a height of less than 100 ft., of the coast between the River Yser and Middlekerke, together with other vertical photos of the area from a greater height. These air photographs were mainly responsible for the information about the positions of the hostile batteries. The oblique photos were taken in three trips. On the first trip the aeroplane flew along the coast at full speed from our lines, and after reaching Middlekerke turned straight out to sea, and thence returned to its aerodrome. The enemy were taken completely by surprise and the aeroplane was unmolested. The next trip, necessitated by some gaps in the line of photographs, was carried out in the opposite direction, and the aeroplane approached Middlekerke from the sea and worked along the coast towards our lines. It came under a very heavy fire and was eventually brought down on the beach about two hundred yards east of the River Yser. The pilot and observer, who were unhurt, extricated themselves and ran to the river, pursued by Germans. They threw off their clothes and swam the river (though one of them had to leave his one remaining garment on some barbed wire in the river), and were then accosted and eyed with great suspicion by a British soldier, who took them off, as they were, to his Commanding Officer. They were eventually rescued.

As the model was confined to the area of the intended landings it was obviously important to guard it carefully, so that no information of this vital matter could by any possibility leak out. The hut was therefore guarded closely by sentries, who refused admission to anyone who was not provided with a special pass from Divisional Headquarters. At first only senior officers were allowed to study it, and it was decided that the men should only be shown it at the last moment, when it was intended that each section should be

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brought into the hut, and its exact rôle on landing pointed out to it and explained on the model. By this means it was hoped that every man would understand clearly what was expected of him, and hesitation and confusion would be avoided.

*Tactical Training of the Troops.*—The training of the troops for open warfare had also to be undertaken. The vast majority of them had had no experience of anything but trench war, and a war of movement was an entirely new conception. However, they threw themselves with a will into this new form of training, and before very long a great improvement was noticeable. The task was rendered somewhat easier by the fact that the country round Le Clipon camp was very similar in its characteristics to that in which they would be called to operate. Schemes were prepared for the various Brigades and Battalions which reproduced with a fair degree of accuracy the actual tasks they would have to perform, and in this way the scope of the training was narrowed down and kept within reasonable bounds.

It has already been pointed out that it was important to destroy the Raversyde Batteries as early as possible. These were four in number and each consisted of four 6-in. naval guns and were situated between Middlekerke and Ostend. It was decided to dispatch a flying column as soon as possible after landing to deal with them. The column was to consist of a battalion of cyclists, a motor-machine-gun battery, and a detachment of a field company mounted on bicycles, all from the left column. These troops were able to rehearse in the vicinity of Le Clipon camp a very similar undertaking to that they would be required to carry out. It was intended that they should rush the batteries from the direction of Middlekerke, destroy the guns and then withdraw. The batteries were, so far as could be seen, unprotected from the landward side, and it was thought that they could be captured by a *coup de main*, provided the attempt were made without delay. The whole manœuvre was rehearsed more than once by the troops concerned on suitable ground near Le Clipon.

The method to be adopted in actually destroying the guns had to be carefully considered. It was important to keep the weight of explosive, etc., to be carried down to a minimum, and it was considered that if the guns could be rendered ineffective for a few days the object would have been achieved. Consequently, it was decided to experiment with thermite, and some captured German guns were provided by G.H.Q. in order to give the Divisional Engineers some experience of it. It was found to be sufficiently effective to justify its use; the weight required was decidedly less than that of gun-cotton; it was quick to work with, and safe in its action. It was therefore decided to use it, but to supplement it, if time permitted, with some gun-cotton in order to increase the damage done.

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It will thus be seen that the amount of training, both general and special, to be undergone was very considerable.

*Framing the Orders.*—In addition to the training, there was also a great deal of work required in connection with the framing of the actual plan and orders, which involved many consultations with the Navy. The orders to be issued had perforce to be very detailed and it was found convenient to prepare various schedules as appendices to the general order, each schedule dealing with one particular matter or phase. In describing the plan of operations here, it will be convenient to deal with it in its five main phases, as under :—

1. Embarking the landing force.
2. The sea voyage.
3. The landing.
4. Operations of the XV Corps.
5. Exploitation.

*Embarking the Landing Force.*—It was decided that the embarkation should take place at the Dunkirk Docks and the Naval vessels were to rendezvous there during the night before the date fixed for embarkation. It was, of course, necessary to reduce to a minimum the period when the monitors and pontoons should be in the vicinity of Dunkirk, as their presence was likely to become known to the enemy. To reduce this danger to a minimum, arrangements were made by the Navy to camouflage the pontoons while they were lying in Dunkirk Docks. It was desirable that the loading of the pontoons and the embarkation of the troops should take place after dusk, so as to attract as little attention as possible, but in view of the fact that the whole operation, as far as the Navy was concerned, had to be completed by dawn the following morning, it was found necessary that the loading of the vehicles and stores on to the pontoons, which was a somewhat lengthy process, should take place in daylight. The troops were to embark after dusk, and the flotilla would get under way as soon as possible after the embarkation was complete. Since the troops would be very much crowded on board the ships, it would not be possible for them to have any substantial meal while on board. It was therefore necessary to give them one just before leaving camp, and the Navy agreed to serve out hot chocolate to them at some time during the voyage. This was all that could be done, beside the provision of food carried by the men on their persons.

Divisional Headquarters was to be conveyed by a small monitor (M.25) independently of the rest of the flotilla, and was timed to start some time after the other ships.

*The Sea Voyage.*—The voyage itself was timed to commence after dusk. The Naval arrangements, together with a list of the ships detailed to take part in the enterprise, are fully given in *The*

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*Dover Patrol.* The monitors and pontoons were to be preceded by a number of small craft, whose duty it was to make the smoke-screen to cover the landing. In order to mislead the enemy it was intended that smoke-screens and feints by other ships should be made in the neighbourhood of Zeebrugge for some days preceding the day fixed on for the actual landing, and on that day there should be intense activity all along the coast as far as the Dutch frontier. Thus it was hoped that the enemy would be mystified, and would be kept in ignorance of the actual place of landing.

During the voyage a telephone cable was to be paid out by the M.25, so that Headquarters 1st Division might be in continuous telephonic communication with Fourth Army H.Q. near Dunkirk. Arrangements were also made for one of the monitors in each group to pay out a cable from a central point marked by a buoy, and that these cables, together with the one laid by M.25, should be brought together into a junction box and eventually taken ashore. By this means Divisional Headquarters would be in constant touch with the three Brigades by means of submarine cable, both before the landing and after it had taken place. Supplementary means of communication were provided by W/T to the three Brigades and the Fourth Army, and by pigeon to the latter. Visual signalling would also play its part as soon as the smoke-screen had dissipated.

*The Landing.*—The landing itself was timed to take place at dawn. It was also necessary that it should take place more or less at high tide, so that the troops should have the shortest distance to cross before reaching the wall. These two conditions naturally limited very greatly the number of suitable dates on which the landing could take place, and, as has already been pointed out, the conditions of wind and weather had to be favourable, *i.e.*, there had to be a sea-breeze in order to drive the smoke-screen forward, but not strong enough to raise a rough sea on the beach. Finally, it must be remembered that the enterprise was only to be attempted if and when 5th and 2nd Armies at Ypres had made sufficient progress and had reached Staden. It is clear that the chances of focussing all these conditions on to one date were not too great—and, as it turned out, the enterprise was never attempted, owing to the non-fulfilment of the last condition. It was, however, necessary to fix beforehand the earliest date on which the first two conditions would be fulfilled, *i.e.*, high tide about dawn, and to make all preparations for landing to be carried out on that date subject to the other conditions being favourable. As regards the weather conditions, which played such an important part in the success of the enterprise, it was, of course, impossible to count on this beforehand, although full and frequent "Meteor" forecasts were arranged for; and it is of interest to note that on none of the successive dates which were chosen as satisfying the "time and tide" condition was the weather

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really favourable, though perhaps just possible on one or two dates. On the majority of the dates it was frankly impossible.

The plan for the actual process of landing was simple. The monitors, after making the cable telephonic communication with the M.25, as has already been described, were to go straight to their respective stations and push their pontoons directly towards the shore. As soon as the monitors got within a certain distance (about 300 yards) of the shore they were to open as rapid a fire as possible with all their guns, which could bear, 12-in., 6-in., 12-pdr., etc., on the houses and defences on the immediate sea front. It must be remembered that the movement of the flotilla towards the shore was to be covered by smoke along the whole length of coast-line—so that the shooting of the naval guns would perforce have to be blind. The range, however, was extremely short, the firing was absolutely point-blank, and it was confidently expected that the fire would be effective. It was, moreover, more on the moral effect of this fire than on the material effect that reliance was to be placed, and it was felt that the moral effect was bound to be tremendous. The number and weight of guns employed (four 12-in. and several 6-in. in each group) the smoke, the time of day, would all combine to this end, and it was hoped that the morale of the German machine-gunners would be seriously shaken before ever the infantry attack was launched. This naval bombardment was timed only to last a few minutes, five at most, and then the infantry and tanks were to pour ashore. The two male tanks, followed by the female tank, would climb the wall and deal with centres of resistance in an ever-widening area, while the infantry secured their footing ashore, "mopped up" and consolidated.

It must be borne in mind that every infantry section had its allotted task, and knew exactly what was expected of it, thanks to the model in Le Clipon camp.

Parties of R.E. were detailed to accompany the leading waves, in order to deal with any unexpected obstruction met with on the wall or beyond.

It was believed that the wire defences on the wall had been electrified, and the R.E., and some of the leading infantry as well, were provided with rubber-handled shears with which to cut the wire. Incidentally, it may be mentioned that arrangements were made to deal with the power-house, which was thought to have been located, by means of heavy gun-fire from the XV Corps area a day or two before the date selected for the landing.

The Pioneer Company in each landing was at first given the task of clearing the pontoons of all vehicles and stores, so that the naval units could withdraw before the smoke-screen came to an end.

The objectives given are shown in *Map* No. 2. The first objective, as will be seen, was very close, and consisted merely in gaining a

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footing ashore. There was, however, to be no pause on the first objective, but the troops were to push on as rapidly as possible to the second.

*The Attack of the XV Corps.*—At the same time as the 1st Division landing was to take place, or rather, shortly afterwards, the XV Corps was to attack in a N.E. direction from Nieuport and Nieuport Bains. Some of the ground to be covered by this attack is shown in *Photo* No. 4. The attacks of the XV Corps and the 1st Division would naturally afford each other a great deal of mutual help. The XV Corps had a difficult task, involving the crossing of the Yser on part of their front, but the 1st Division landing, and especially the right and the centre landings, were expected to neutralize almost entirely the fire of the German batteries supporting the Yser front, since these batteries were mostly located in the area immediately affected by these landings. As a matter of fact, the Germans had but little choice in the matter of the siting of their batteries. They were practically tied up to the little strip of raised and undulating ground on the coast, as the ground inland was very flat and water-logged. This fact constituted a real weakness of the German position, and it was hoped that the 1st Division would be able to turn it to very good account, and render comparatively easy what would otherwise have been a very difficult task for the XV Corps to accomplish.

*Exploitation.*—The left Brigade of the 1st Division, as has already been mentioned, was to send a flying column as soon as possible after landing to deal with the Raversyde batteries between Middlekerke and Ostend, since it was necessary to silence these batteries in order to give to the naval vessels liberty of action, and thus secure the sea communications of the 1st Division.

The flying column consisted of one cyclist battalion, one motor machine-gun battery, and a detachment of R.E. on bicycles.

The R.E. carried with them thermite and gun-cotton for the purpose of putting the 6-in. coast defence guns out of action, and, as has been explained, had been practised in their use. The flying column was to return as soon as possible after completing its task, as it was considered necessary to avoid any dispersion of force, in view of possible counter-attack by superior forces of the enemy. Nor was there any reason why the flying column should stay out at Raversyde, as the batteries would be innocuous even after the column had withdrawn. This column would also be required for exploitation, which would take place in an easterly or south-easterly direction, with a view to threatening the line of retreat of the German Divisions further south. There was no intention of moving direct on Ostend, but rather of isolating it by a movement to the south of it. These were the reasons for the intended immediate withdrawal of the flying column as soon as its task had been accomplished. The withdrawal

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was to be assisted by a battalion moved out from Middlekerke towards Raversyde in support of the column.

As soon as the second objective had been gained, strong patrols of cyclists with motor machine-guns were to be pushed out towards Leffinghe and Slype with a view to occupying the bridges over the canal and the various road junctions. The country was of such a nature that movement had to be very largely confined to the roads, and the occupation of the points mentioned would have important results. But the 1st Division would not be in a position to go very far afield, on account of the total absence of horsed transport. It could not, therefore, hope to do much more than gain the second objective and carry out the other tasks mentioned above, until it was joined by its transport. It was hoped that this would be possible on the first night after the landing, and it was intended to pass the transport over the Yser near its mouth and to move it along the beach to join the Division. It was not possible, of course, to count on this, and for this reason the Division had to be prepared to carry on without its transport, but it was fully realized that so long as its transport was absent its mobility would be greatly impaired, and anything like exploitation would be out of the question. It would also have very meagre artillery support—a matter of only 12 18-pdrs. and 6 4·5-in. howitzers, and for these the ammunition supply would be very strictly limited.

The replenishment of supplies by sea also could not be counted on unless the Raversyde batteries had been silenced, although the Navy did intend to attempt to run barges ashore loaded with various stores. However, in view of the importance of exploiting success without any delay and the big results that might have attended that exploitation, it was decided to make every effort for the horsed transport to rejoin the Division *via* the beach the first night after the landing. To this end arrangements were made for the horsed transport to move up to some convenient place in the neighbourhood of La Panne, and from there move forward as early as circumstances would allow to cross the Yser at Nieuport Bains.

*Divisional Control of the Operations.*—The question of Divisional Control of the operations was a difficult one. It will be remembered that Divisional Headquarters on the M.25 was to be connected by submarine cable with the three infantry Brigades both before landing and after it had been effected, and after Divisional Headquarters had gone ashore it would still have the communication, as the ends of the cable would also have been taken ashore. In view, however, of the great congestion likely to occur on the shore at the points of landing immediately after the landing had taken place, and of the difficulty of controlling the operations of the Division as a whole in such circumstances, it was decided by higher authority that Divisional Headquarters should not land until a firm

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footing had been gained on the shore, and that it would then move to some point in the centre Brigade area. This decision involved a certain amount of delay, and it was calculated that the movement ashore of Division Headquarters could not take place until the supply of smoke-producing materials for the smoke-screen had been exhausted. The landing, therefore, would have to be carried out in view of the guns of the coast batteries towards Ostend, a prospect which was not relished by those concerned.

The Divisional reserve was at first to consist of one battalion of the right Brigade, and it was hoped that, as the advance of the XV Corps progressed, it would be possible to pinch out the whole of this Brigade, which would then form the Divisional Reserve.

*Conclusion.*—Such generally was the scheme of operation and the method by which it was intended to prepare for it.

It was never put into execution, since the progress of the 2nd and 5th Armies east of Ypres was not sufficient to justify this being done. One can therefore only conjecture what would have happened had the project been carried out. It is evident that the chances of success depended very largely on the element of surprise. It was believed at the time that that surprise would have been absolute had the landing been made on the first date arranged for it. After that time the Germans were probably aware of the fact that a landing was contemplated, but remained in ignorance as to the time and place. Thus even at a late date it is probable that a local surprise would have been effected. If so, it is barely conceivable that the Division would have failed to get a good footing ashore, and, if once that was done, it was felt that it would have been able to hold what it had gained. It must be remembered that the area of possible enemy counter-attacks would have been very much restricted by the marshy ground, and that his mobile artillery would have been largely put out of action by the very fact of the landing. Further, the attack of the XV Corps would have inevitably taken up a large proportion of the energies of the German troops. For these reasons, to say nothing of the splendid fettle the men were in, the 1st Division was sanguine of success. The results of success would almost assuredly have been very far-reaching. It was not too much to hope that the diversion on the coast would have very materially assisted the operations of the 2nd and 5th Armies. Ostend would probably have fallen into our hands, and Zeebrugge would have been neutralized if not captured. Thus a large portion of Belgium would have been recovered, the naval aspect of the war entirely changed, the morale of the allies raised, and that of the enemy lowered. The effect in Germany of such a tangible result might have anticipated by fifteen months her realization of failure. But this is all surmise; the fact remains that the landing was not attempted, and the war dragged on for more than another year.

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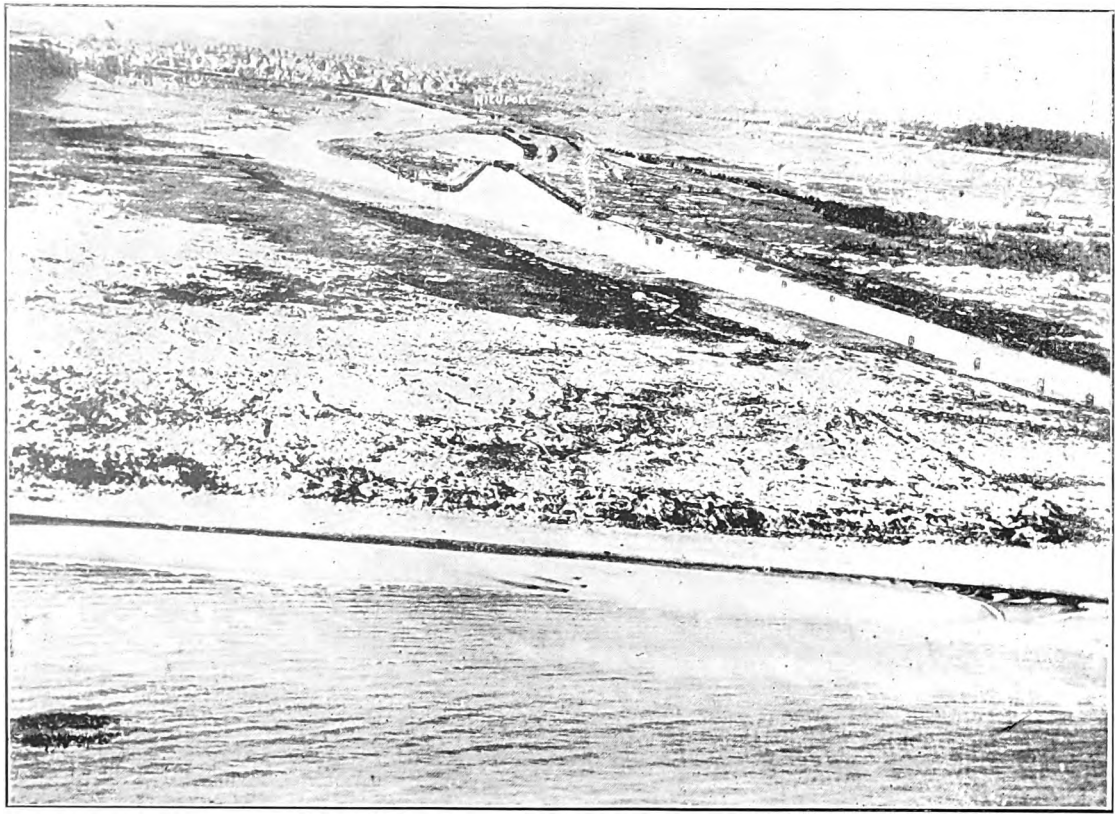

**Photo No. 2.—Showing part of area on East Bank of the Yser; seized by the Germans on 10th July, 1917.**

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Photo No. 3.—Middlekerke—the Site of the Proposed Left Landing of the 1st Division.

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Photo No. 4.—Looking East—showing Area of Proposed Attack of XV. Corps.

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# THE OPERATIONS OF THE 1ST DIVISION ON THE BELGIAN COAST IN 1917.

## MAP No. 1.

## Scale 250,000.

Miles 5 4 3 2 1 0 5 10 15 Miles

Zeebrugge
Blankenbergh
Dutch Belgian Frontier
Ship Canal
Leopold Canal
Ostend
Bruges
Canal
Ravensyde
Middlekerke
Westende
Canal
Nieuport Bains
Lombartzyde
Ghistelles
Coxyde Bains
Nieuport
La Panne
Canal
Ryser
Furnes
Thorout
Le Clipon camp
Le Clipon
Dunkerque
Franco-Belgian Frontier
Dixmude
Gravelines
Bourbourg Ville
Canal
Thielt
Staden
Merckem
Houthoulst Forest
Roulers
Poelcapelle
Boesinghe
Pilkem
Passchendaele
Elverdinghe
Zonnebeke
Poperinghe
Ypres
Hooge
Becelaere
Gheluvelt
Courtrai
Cassel
St Omer
Menin
Mouscron
Hazebrouck
Tourcoing
Wattrelos
Armentieres

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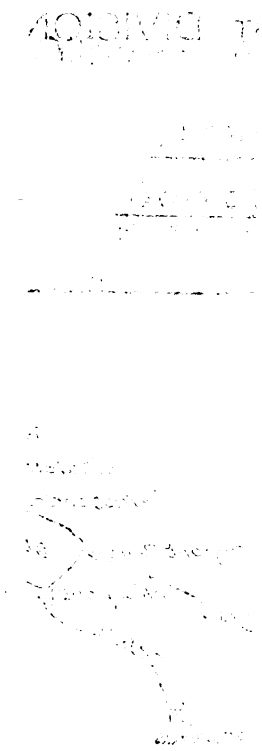
Photo No. 4.—Looking East—showing Area of Proposed Attack of the 1st Infantry. Published by the permission of the Air Ministry.



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# THE OPERATIONS OF THE 1ST DIVISION ON THE BELGIAN COAST IN 1917.—MAP No. 2.

1st Objective of 1st Div. ——

2nd " " " " - - - - -

Objective of XV Corps. .....

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# *THE DHILWAN CREOSOTING PLANT*

*By* MAJOR H. L. WOODHOUSE, M.C., R.E.

FOR many years the North-Western Railway of India depended entirely on deodar for its wooden sleeper supply. Before the war, prices were gradually rising as the demand increased and the most conveniently situated forests were worked out, but during and after the war they rose to prohibitive heights. There are many other trees growing in the Himalayas which are quite suitable for conversion into sleepers so far as their mechanical strength goes, but liability to decay, or to attack by white ants, renders them useless unless some method of treatment is applied. In 1920 it was decided to make use of these trees for sleeper supply, and the Dhilwan plant was designed to overcome their defects by creosoting them.

2. The effect of creosoting sleepers is to force creosote, either pure or mixed with some cheaper oil, into the pores. A penetration of about three-quarters of an inch into the sides is sufficient to preserve the sleepers from decay or white-ant attack till their mechanical life comes to an end, either by the rail seat failing or the spikes losing their grip. By the time such a penetration into the sides is attained, the creosote has worked up the fibres at the ends for about six inches. Penetration into sap wood is much easier than into heart wood, and into any decayed wood easier still. The creosote stops the decay, and sleepers with slight decay are not seriously injured, though any decay is, of course, objectionable. Owing to this limited penetration, spike holes should be bored before treating the sleeper, otherwise untreated wood is exposed when the boring is done. Unfortunately experience has shown that the width of the rail flange varies enough to disturb the gauge, when boring is done before treating, and experiments are still in progress to overcome this trouble. It seems probable that one rail seat only can be bored before treating, and the spike holes for the other rail seat will have to be bored after the sleeper is put in the line; in which case all that can be done is to swab the holes after boring with creosote; a partial protection, but nothing like so effective as if creosote at a high temperature and pressure had been forced into the hole while the sleeper itself was being treated.

3. Dhilwan is on the N.W.R. main line where it crosses the river Beas. The site is not ideal, but was chosen in the belief that the majority of sleepers for treatment would be floated down the river.

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This expectation has not, so far, been justified. The depôt is about half a mile from Dhilwan station, on the river bank, and the level of the subsoil water is so near the surface in the flood season that there have been considerable difficulties with the underground tanks. Dhilwan station itself is only a small wayside station, hence shunting of sleeper and creosote wagons into the depôt has either to be done by train engines, causing delay to traffic, or by a special shunting engine whose cost is considerable. This trouble will be overcome when the petrol shunting engine now on order arrives. On the other hand, owing to the soil being chiefly fine river sand, there have been no difficulties as yet from white ants attacking the untreated sleepers while they are seasoning.

4. The treating plant consists of a cylinder 75 ft. long by 7 ft. 6 in. diameter. This accommodates eight trucks at a time or about 360 sleepers. Below the cylinder is a low-service tank about 70 ft. long, 8 ft. wide, and 6 ft. deep. This tank was built of brick and concrete, to which a lining of lead sheeting has been added. Both cylinder and tank have steam pipes running through them for heating purposes. They are covered by a corrugated-iron shed with brick side walls and open ends, while the space between the cylinder and the tank is filled in with wooden shutters to keep dust out of the tank. Outside the shed is an iron high service tank on iron staging about 10 ft. above the top of the low service tank. The pump and boiler house abuts the shed, with which it communicates by a door. It contains a Lancashire boiler, a water feed pump, two pressure pumps and two vacuum pumps. A control board is now being fitted, on which all the dials and gauges connected with the cylinder will be concentrated, thus making the pump-house the control centre.

5. The treating mixture of creosote and fuel oil is stored in five double tanks of brick and concrete near the cylinder shed. These are buried in the ground, and have had to be lined, in some cases, with lead-sheeting, in others with iron sheeting, and in others with canvas and pitch. They are not really satisfactory, even with the linings, and steel tanks above the ground would probably have been cheaper and certainly more efficient. A siding runs alongside these tanks and the creosote or oil is run in direct from the tank wagons. An iron pipe joins the tanks to the pumps. The distance from tanks to pump is rather great and it may be found necessary to install another pump nearer the tanks to assist. The holding capacity is about 650 tons of mixture, rather more than one-and-a-half month's supply when the cylinder is working at full speed. Each tank has a nest of steam pipes, fed from an independent boiler for the row of tanks, to keep the creosote liquid in cold weather and to prevent it from depositing its heavier constituents as solids. Napthalene is received as a solid in barrels and is added to the mixture in the low

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service tank. If sent up as part of the liquid creosote, it would be liable to separate out in the travelling tanks in any but the hottest weather.

6. An adzing and boring machine, made by Robinson of Rochdale, cuts the ends off sleepers over 9 ft. long, adzes, and bores them. Its capacity, sawing and adzing only, is about 1400 sleepers a day, but if boring is to be done, the output falls to about 800. Power is supplied by a portable engine and the whole plant is covered by a shed. A second machine of older pattern, which cannot trim the ends of the sleepers, is now being erected in a similar shed about 100 ft. away and on the opposite side of the trolly line. The space between is required for stacking sleepers which are too wide to go through the machine and have to be adzed by hand.

7. Near these machines a large shed is being erected in which a month's supply of sleepers will be kept. This will ensure that sleepers treated during the rains are dry—an important matter.

8. Further proposals are the installation of an incising machine to make incisions in the top and bottom of certain kinds of sleepers, particularly fir, which have difficulty in absorbing the mixture, and a saw-sharpening machine.

9. A system of 2 ft. 6 in. tramways is laid all over the depôt. They interlace with the broad-gauge fan of sidings. Two small engines are in use at present and a third is expected shortly. Ordinary four-wheel trucks are used for moving sleepers about the depôt, and special trollies with 4-in. wheels are used for running sleepers into the cylinder. These trollies have projections which engage with two bars running the length of the cylinder and hold the trollies on the rails. Otherwise, when the mixture enters the cylinder, the sleepers floating in it would lift the trollies off the line. In common with the rest of the plant, these engines burn a mixture of coal and wood blocks trimmed off the ends of the sleepers. Transhipping platforms of earth, revetted with corrugated iron are placed between each broad-gauge siding and its corresponding narrow-gauge siding. A Simplex petrol tractor for the broad gauge is being ordered for shunting in the yard and between the yard and Dhilwan station.

10. With anything up to 450,000 sleepers in the depôt, fire protection is very important. A steel 12,000-gallon high-service tank stands on a brick tower in the middle of the depôt. It is fed by two independent pumps, each driven by a Petter oil engine. The latter were installed in preference to steam-driven pumps, owing to the rapidity with which they can be set to work. In a bad fire, such as might result from incendiarism, the tank would be empty before steam could be raised to start steam pumps. A series of hydrants are dotted about the depôt, fed from the high service tank, and hoses are kept ready for immediate use. The sleepers themselves

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are stacked in lots, each containing sixteen piles of 125 sleepers. Between the lots wide fire lanes are left, and piles of sand, each with four fire-buckets full of water, are distributed along the lanes. Fire drills are held at least once a fortnight, and special men are detailed for duty at night.

11. It is necessary to ensure that sleepers are thoroughly seasoned before treatment. Supply is arranged to ensure that all sleepers spend six months in the depôt before they are used. Owing to the practical cessation of deliveries between August and November, ten months' supply has to be in hand at the beginning of August. At the present time there are considerably more in stock, owing to various factors, but the surplus is being steadily worked off. In the hot weather very dry and hot winds blow at Dhilwan, which season the sleepers most effectually. Difficulties occur through the liability of fir to rot, and of *chir* to warp while seasoning.

12. At present fir and *chir* are the principal sleepers being treated. The former are rather soft, are apt to split, are rather difficult to treat, and are liable to decay while seasoning. Their spike-holding qualities are not too good, and their useful life probably not so long as *chir*. On the other hand, they are very cheap. *Chir* is more expensive, but is known to be satisfactory. Its principal defect is liability to warp while seasoning. *Kail* and *asna* are also being treated in small quantities. They are rather expensive, but are known to be very good. The difficulty of treating fir will be reduced when the incising machine is in use.

13. The sleepers are received from contractors at various stations on the N.W.R., of which Marala and Jagadhri are the principal. They are passed by sleeper-passing officers and sent by rail to Dhilwan, where they are unloaded and stacked for seasoning. They are then loaded on narrow-gauge trucks and run to the back of the adzing and boring machine. Having passed through this machine, they are loaded on cylinder trollies as they emerge, and these trollies are then pushed into the cylinder in rakes of eight. The door is closed and a vacuum created to dry out any moisture, and to open the pores of the timber. Ten to fifteen minutes later a valve is opened and mixture sucked in from the low-service tank. When no more can be sucked in the valve is closed, and more mixture run in from the high-service tank, after which still more is forced in by the pumps. All this time the mixture is kept at the requisite temperature by the steam pipes. The pressure is maintained for about half an hour, the time varying with the particular sleepers being treated. The pressure is then released, the bottom valve opened and what is left unabsorbed of the mixture allowed to run back into the low-service tank. An arrangement of valves is now being fitted which will allow of air being pumped into the top of the tank to expedite the expulsion of the mixture. When the cylinder

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is empty, a vacuum is again applied for a short time to clean the sleepers of mixture hanging on the surface, or in some cases to withdraw a certain quantity from the interior if too much has been forced in. The far end of the cylinder is then opened and the rake of trucks withdrawn, and taken to one of the transhipping platforms, where the sleepers are piled and later on loaded into broad-gauge wagons to be conveyed to their destination. The amount of mixture absorbed varies with the temperature and pressure, and with the time during which the pressure is maintained. It is measured by the difference in level in the high and low pressure tanks before and after the process, after making corrections for the difference in temperatures. A further check is ensured by weighing a few marked sleepers in each load before and after the treatment.

14. The actual mixture to be used has not been settled: at present equal quantities of creosote and fuel oil are mixed. Some sleepers have been treated with a mixture of 2 creosote to 1 oil. In America experiments are being tried with 30 per cent. only of creosote. As the creosote is considerably more expensive than oil, the less creosote required, the cheaper the treatment. The whole object of treating being to give the sleepers a physical life equal to their mechanical life, any creosote used beyond that required for this life is wasted. About twelve years is the life at present expected, and to give this, 28 lbs. of mixture are pressed into fir and 24 lbs. into *chir* sleepers. The time required to press in this quantity is such that in a nine hours' day four rakes are treated, or about 1,400 sleepers.

15. As sleepers emerge from the adzing and boring machine they are branded with a letter showing their species, and a figure showing their year of treatment. After they have been treated it is impossible to say to what species they belong without cutting them up. A register is kept showing details of treatment of each batch, amount of mixture absorbed and composition of mixture, and destination to which the batch is sent. From this it will be possible to give the history of any sleeper at any time in the future. Certain experimental sleepers have a second letter added to their identification marks to facilitate their identification when in the line.

16. In addition to the creosote treatment two other methods are to be or have been tried. The first was the use of settled wood tar from the Mysore Distillery in place of creosote. This, mixed with fuel oil, gave trouble owing to the pitch in solution in the wood tar being precipitated by the fuel oil, tending to block the pipes and valves. The red lead joints of the piping also suffered, being attacked by acetic acid in the tar. The penetration into the sleepers was not so good as that of the creosote mixture, as the pitch tended to block up the pores. A second method which is to be tried shortly is Durol treatment. This is a salts treatment used in Italy and France. It has long been known that impregnating timber with

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various salts is an effective means of preservation. In the past, however, no salts treatment has been able to withstand the heavy Indian rains, as the preservative has gradually been washed out of the wood. Durol is said to overcome this defect.

17. The cost of treatment with creosote and fuel oil in equal proportions averages about Rs. 2. 4. 0. per sleeper. This includes all charges, including interest and depreciation. Creosote itself costs Rs. 9. 13. 0. a cwt., f.o.r. Calcutta, and a further 14 annas a cwt. for carriage charges. Settled tar costs only Rs. 5 a cwt. but carriage charges are larger. Durol, if successful, will cost about Rs. 1. 8. 0. or thereabouts per sleeper, so far as can be judged. It is very indefinite as yet. Assuming a twelve-year life for treated sleepers, which seems reasonable, the creosoted soft wood sleeper at its present contract price works out somewhat cheaper economically than deodar. There is no reason to suppose that the difference in price between the two sorts of sleeper will be reduced, so the trial of soft wood appears to have justified itself.

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# *NOTES ON THE EARLY YEARS OF THE ORDNANCE SURVEY.*

(*Continued.*)

## II. The Beginning of Accurate Surveys. 1783–1790.

**Scheme for a General Survey.**—In the *Philosophical Transactions* of the Royal Society for the year 1785, Roy writes an *Account of the Measurement of a Base on Hounslow Heath*, and in the introduction to this account he remarks that, if a country has not actually been surveyed, or is but little known, a state of warfare generally produces the first improvements in its geography. He goes on to say that, "on the conclusion of the peace of 1763 it came for the first time under the consideration of Government to make a general survey of the whole island at public cost. Towards the execution of this work, whereof the direction was to have been committed to my charge, the map of Scotland was to have been made subservient, by extending the great triangles quite to the North extremity of the island, and filling them in from the original map." He then points out that the American war put back this scheme. He continues, "in the course of my ordinary employments, wherein the best opportunities have offered of acquiring a thorough knowledge of the country, I have not failed to observe, at least in a general way, such situations as seemed to be the best adapted for the measurement of the bases that would be necessary for the formation of the great triangles."

After the peace of 1783 official business detained him in or near London the whole of that summer. He took the opportunity, "for my own private amusement," to measure a base about a mile-and-a-half long across the fields between "the Jew's-Harp near Marybone and Black Lane near Pancras; as a foundation for a series of triangles, . . . for determining the most remarkable steeples and other places in and about the Capital."

He was engaged in making some computations for the purpose when he learnt of an important scheme for the execution of a triangulation to connect the observatories of Greenwich and Paris. The history of this scheme deserves to be put on record in some detail, for here we have the origin of accurate mapping in the British Isles.

**The Third Cassini.**—The third Cassini, Cassini de Thury (1714–1784 came of a line of astronomers and geodesists. He was a genuine

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enthusiast in matters geodetical, and we may picture him as having the same driving force as Gill, in later times. In the year 1783 he wrote a "Mémoire," which was transmitted to Mr. Fox by the French Ambassador, Count d'Adhémar. The British Government referred the matter to the President of the Royal Society. There is a copy of the "Mémoire" preserved by that Society, and that copy has a docket on it, "*From Ct. d'Adhémar, 7 octr. 1783*"; but the "Mémoire" was not printed in *Philosophical Transactions* until 1787. The following is the text of it :—

**Cassini's Mémoire.**—*Sur la jonction de Douvres à Londres. Par M. Cassini de Thury, Directeur de l'Observatoire Royal; de la Société Royale de Londres, etc.*

"Il est intéressant pour le progrès de l'astronomie que l'on connaisse exactement la différence de longitude et de latitude entre les deux plus fameux observatoires de l'Europe; et quoique les observations astronomiques faites depuis un siècle offrent un moyen assez exact pour parvenir à cette recherche, il parait cependant que l'on n'est point d'accord sur la longitude de Greenwich à onze seconds près, et sur la latitude à quinze seconds.

L'on a reconnu par les opérations trigonométriques exécutées en France, au Nord, et au Pérou, que sur l'étendue d'un degré du méridien ou de 57 mille toises, l'on se trompait à peine de dix toises, ce qui a été prouvé par des bases mesurées à l'extrémité des suites de triangles; ainsi sur la distance de Douvres à Londres, qui est de 49,800 toises ou environ, on ne pourrait se tromper de 120 toises, qui repondent à onze seconds en longitude.

M. Cassini a déjà publié, dans le livre de *La Méridienne Vérifiée*, les opérations par lesquelles l'on a déterminé la distance de Calais à la grosse tour de Douvres de 18,241 toises par un premier triangle, et de 18,243 toises par un second triangle; on aurait cette distance avec une plus grande exactitude en observant les angles conclus à Douvres, qui sont fort aigus. M. Cassini a découvert des côtes de France plusieurs objets sur les côtes d'Angleterre, qui seront visibles de la tour de Douvres; et sur cette première base on établirait une suite de quelques triangles jusqu'à Londres, dont le nombre et la grandeur dépendent de l'exposition des objets compris dans la direction de Douvres à Londres.

M. Cassini ne doute point que ce projet ne soit agréé d'un Souverain qui aime les sciences, qui, non content des découvertes du célèbre Cook, vient d'ordonner un second voyage autour du monde, et que la Société Royale ne charge un de ses membres de l'exécution; et dans le cas où ses occupations l'empêcheraient de s'y livrer, qu'elle ne permît à M. Cassini de s'en charger. L'honneur qu'elle lui a fait de l'associer à un corps aussi respectable serait un titre pour lui accorder sa confiance. M. Cassini a profité du voyage du Roi en Flandres en 1748 pour joindre les triangles de la méridienne à ceux de Snellius en Hollande; en 1762 il a prolongé la perpendiculaire de Paris jusqu'à Vienne en Autriche. La branche qui s'étendra jusqu'à Londres sera la troisième, et formera la jonction des deux plus belles villes de l'Europe.

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**Effect of the Mémoire.**—This communication was made at a very opportune time, but it must be confessed that its first paragraph is tactless to a remarkable degree. It states roundly that the latitude of Greenwich was in doubt by some fifteen seconds, and that in order to determine the correct value it was desirable to connect Greenwich geodetically with Paris! To such a statement objection was naturally taken by the Astronomer Royal, Dr. Maskelyne, who wrote an answer which was published in *Philosophical Transactions* immediately after the Mémoire—but not until 1787. Maskelyne says that "the latitude of the Royal Observatory at Greenwich is firmly established by Dr. Bradley's observations and my own at 51° 28′ 40″, probably without the error of a single second."

He further says: "The extensive geometrical operations recommended by the late M. Cassini de Thury [Cassini died in 1784], and commenced under the direction of Major-General Roy, F.R.S., by his exact measures of a base on Hounslow Heath, may also, when completed, determine the difference of meridians of Greenwich and Paris to great exactness. But they do not seem to me likely to throw any new light on the difference of latitude of the two observatories, because the uncertainty we are still under about the true figure and dimensions of the Earth, and the irregular attractions . . . would prevent us from drawing any accurate conclusions."

There can be no doubt that Maskelyne was entirely right, and that Cassini was mistaken when he advocated the execution of a geodetic connection between Greenwich and Paris, in order to ascertain the latitude of the former observatory. But he may well be forgiven, for his memorandum was used as a most effective lever by those who desired to put the surveys of this country on a better footing. King George III., to whom the memorandum was submitted, was anxious to oblige the French; the Royal Society was willing to assist in the project to ascertain the difference of the longitude of the two observatories; and Roy, to whom the execution of the scheme was to be confided, looked upon it chiefly as a means of providing an accurate framework for map-making, and stated that the chief and ultimate object "has always been considered of a still more important nature [than the mere joining of the observatories], namely, the laying the foundation of a general survey of the British Islands." There were, thus, several motives at work, political, scientific and practical, and all contributed to the adoption of the proposal.

The King himself took a personal interest in the matter and defrayed the cost of the necessary instruments. The Royal Society undertook the general direction of the work; and the services of Major-General Roy were lent by the military authorities. It was decided to observe the angles with "a large circular instrument,"

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or theodolite, and Jesse Ramsden, the finest instrument-maker of the time, was entrusted with its construction.

**Ramsden.**—According to the *Dictionary of National Biography*, Jesse Ramsden was born in 1735, his father being an inn-keeper at Halifax, Yorkshire. He was apprenticed to Burton, a mathematical instrument-maker in the Strand, in 1758. In 1765 he married the daughter of John Dollond, the optician. He was a man of marked ability, and the "artist's genius disdained time restrictions." Later on we shall see how great a trial this dilatory artist was to Roy. "On one occasion he attended at Buckingham House precisely as he supposed at the time named in the royal mandate. The King remarked that he was punctual as to the day and hour, while late by a whole year." In 1777 the Commissioners of Longitude published the description of his *Engine for dividing Mathematical Instruments*. He made large numbers of the finest astronomical instruments of his day. "The demand from all parts of Europe for his incomparable instruments was greater than could be satisfied by the constant labour of 60 workmen." Delambre styled him "*le plus grand de tous les artistes*." He was elected a Fellow of the Royal Society in 1783, and in 1795 he received the Copley medal. He died in the year 1800, leaving behind him the memory of an upright, kindly man of genius, absorbed in his work. His portrait by Robert Hume is in the rooms of the Royal Society.

**The Great Circular Instrument.**—The great three-foot theodolite, which was presented by the King to the Royal Society, (no doubt after discussions as to its design between Sir Joseph Banks, Ramsden, Roy and Maskelyne), was apparently ordered in August, 1784. It is the father of accurate theodolites. The horizontal circle of brass, 3 ft. in diameter, is divided by dots into spaces of ten minutes; there were originally two micrometer microscopes for reading this circle; angles can be read to tenths of seconds. This was the first instrument capable of detecting spherical excess. It weighs about 200 pounds, and was carried when travelling in a four-wheeled spring van. It is now preserved at the Ordnance Survey Office at Southampton. It is known as the 3-*ft. Theodolite R.S.*, to distinguish it from a similar instrument, ordered subsequently by the Board of Ordnance, and known as 3-*ft. Theodolite B.O.* The former instrument was first used in 1787 and was last used in 1853; having thus been in use for 66 years.

**Hounslow Heath Base.**—Roy says that "a generous and beneficent monarch, whose knowledge and love of the sciences are sufficiently evinced by the protection which He constantly affords them, and under whose auspices they are seen daily to flourish, soon supplied the funds that were judged necessary." Having thus the goodwill of the highest authorities in the State and in the scientific world, it was not long before a beginning was made. Roy suggested that

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a base should be measured on Hounslow Heath, and on the 16th April, 1784, a day much to be remembered, the President of the Royal Society, General Roy, Dr. Blagden and Mr. Cavendish, began the examination of the ground at King's Arbour and finished at Hampton Poor-House, near the side of Bushey Park, a distance of some five miles. "Chiefly with a view to the more effectual execution of the work, it was judged to be a right measure to obtain and employ soldiers, instead of country labourers, in tracing the base, clearing the ground, and assisting in the subsequent operations. They would furnish the necessary centinels for guarding the apparatus. . . . Accordingly a party of the 12th regiment of foot, consisting of a serjeant, corporal and 10 men, was ordered to march from Windsor to Hounslow Heath, where they encamped on the 26th May."

Volunteers, for assisting in the preliminary measurement, were Lieut.-Colonel Calderwood, F.R.S., of H.M. Horse Guards, Lieut.-Colonel Pringle of the Corps of Engineers, Mr. Lloyd, F.R.S., and Ensign Reynolds, 34th Regiment, who also made a local plan.

It had originally been intended, in accordance with what was then the almost universal custom on the Continent, to measure the base with deal rods, and a set of them was prepared for the purpose. The greatest care was taken in the construction of these rods, but experience showed that variations in humidity caused considerable changes in their lengths, and, after exhaustive trials, the idea of using wooden rods was abandoned.

At the outset of the operations a steel chain had been ordered from Ramsden, "the best that he could make." It is not quite clear why this chain was ordered, for Roy states that it was not intended to accept the result of measurement by its means; he also says that the chain, after some alterations, may be "advantageously applied to ordinary measurement on the surface of the earth." However, the chain was made and used in the rough measurement of the base, which was begun on the 16th June and completed on the 22nd.

The definitive measurement of the base was carried out by most unusual means, namely, by glass tubes. The idea of using these was due to Lieut.-Colonel Calderwood, who "was accordingly requested to make the trial at the glasshouse, as soon as possible after his return to town. Next day he succeeded in getting a fine tube drawn, eighteen feet long and about one inch in diameter." Several tubes were made, one being no less than twenty-six feet long; and Ramsden was entrusted with the work of making them suitable for use in measurement. Very full details are to be found in *Philosophical Transactions*, or in Volume I of the *Account of the Trigonometrical Survey of England and Wales*.

The final measurement was commenced on the 17th August, 1784,

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and was finished on the 30th of the same month. The work excited very general interest. On Saturday, the 21st of August, "about noon, his Majesty deigned to honour the operation by his presence, for the space of two hours, entering very minutely into the work of conducting it, which met with his gracious approbation." The gentlemen who assisted in the last day's operation were "Captain Bisset, Mr. Greville, Sir William Hamilton, Mr. Lloyd and Dr. Usher, Professor of Astronomy in the College of Dublin."

"The respectable and very worthy President of the Royal Society, ever zealous in the cause of science," repeatedly visited the Heath, and in the final stages of the measurement gave his attendance from morning to night "and with that liberality of mind which distinguishes all his actions, ordered his tents to be continually pitched near at hand, where his immediate guests, and the numerous visitors whom curiosity drew to the spot, met with the most hospitable supply of every necessary, and even elegant refreshment."

The length of this base, after applying corrections for temperature and reduction of sea-level, was 27,404·01 ft.

The base was re-measured in 1791, after Roy's death, by Lieut.-Colonel Edward Williams, then Director of the Survey. This time the measurement was carried out with two new chains made by Ramsden. The new value of the base was found to be 27,404·32 ft.

The mean of the two results was thereafter taken as the true length, *viz.*, 27,404·2 ft.

**Standard of Length.**—With regard to the standard of length, Roy states that "at the sale of the late ingenious optician Mr. James Short, I purchased a finely divided brass scale, of the length of 42 inches," reading by verniers to the thousandth of an inch. The scale originally belonged to Graham, the celebrated watch-maker"; has the name of Jonathan Sisson engraved upon it; but is known to have been divided by the late Mr. Bird, who then worked with Sisson. (Bird, an instrument-maker, as deservedly celebrated as Ramsden, died in 1776.) This brass scale was compared with the scale belonging to the Royal Society, which had engraved upon it the length of the standard yard from the Tower, that from the Exchequer, and also the French half-toise. This R.S. scale had been made by Sisson, and a duplicate had been sent to Paris for use by the Royal Academy of Sciences.

**Instrument Makers.**—A recital of the names of these great instrument-makers calls to mind the immense debt which all explorers and surveyors owe to them and to their successors. English instrument-makers were, and are still, for most purposes, the most competent and ingenious in the world. Too often it is forgotten how greatly the success of a geodetic operation depends upon the exquisitely fine construction of the instruments used; too often the observer, whose work, though tedious, is to some extent mechanical,

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is apt to attribute to himself a success which is largely due to the maker of his instruments. Indeed, in this matter it is hard to say which of the trio deserves most credit: the mathematician who devises the theory, the laborious observer who accumulates the facts, or the instrument-maker, whose skill in design and minute accuracy of execution principally contributes to the reliability of the result. These old instrument-makers have had worthy British successors in Troughton, Simms, Cooke, Watts and others.

**The Base Terminals.**—In Roy's time the terminals were marked by wooden pipes, a foot in diameter, with a bore of four inches. In 1791 the wooden pipes were found in a very decayed state and were replaced by guns, placed vertically, muzzle upwards and carefully centred. The guns were selected at Woolwich, by order of the Master-General, and were sent to Hampton by water. Wooden plugs were fixed in the bores, with centre dots marked on them, and iron caps were screwed over the muzzles. These guns still remain in position (1924), the western gun being enclosed by a railing; but the plugs and caps have disappeared.

Roy, in the last communication made by him to the Royal Society —he was correcting the proofs when he died—spoke strongly of the desirability of making indestructible terminals. He said, "these should be low circular buildings, rising but a few feet above the surface of the Heath, composed of the hardest materials such as granite . . . they would resemble those basements of ancient crosses we often meet with. . . . In the interior of this little building, metal tablets would be inserted, containing the name of that much-beloved monarch in whose reign the operation was begun . . . the distance from one another, the angle of the base with the meridian, and also the magnetical variation."

In 1926 we shall be able to commemorate the second centenary of Roy's birth. Perhaps the little circular buildings imagined by him might be built then. They would be appropriate memorials to the founder of the Survey.

**Delays.**—After the measurement of the base on Hounslow Heath the official records have little to chronicle for nearly three years. It was, in fact, impossible to get to work on the observation of the angles of the triangulation, which was to connect London with Paris, because Ramsden took all this time to construct the "great circular instrument." Some useful work was, however, carried out by Lieut. Fiddes of the Engineers, who was permitted by the Duke of Richmond, Master-General of the Ordnance, to be employed, under General Roy, in making a very accurate plan of that part of Romney Marsh where the base of verification was to be measured. This was during the summers of 1786 and 1787.

**Roy's Later Letters.**—We can get some idea of Roy's own activities during this (to him) very trying period, from some of his later letters.

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Thus, on the 10th September, 1786, we find him writing a letter, probably to Dr. Lind at Windsor, which shows that the King continued to take an interest in the work. The letter also shows how much Roy felt the delay caused by Ramsden's dilatory proceedings.

"Having left London yesterday afternoon, it was not till this morning that I received at this place your letter of the 9th; and it gives me great concern that, owing to this accidental circumstance, I could not have the Honour of obeying the Commands therein signified. . . . I could easily have transported myself to Hampstead from whence I should certainly have seen the lights exhibited there. The truth is that my presence was necessary to forward some parts of the apparatus for the Triangular operation, which, notwithstanding every effort of mine, I fear we shall not be able to begin this Season.

"It will be yet some days before Ramsden can possibly finish the Division and after that the semicircle for the uppermost telescope is to divide, the levels to adjust, and a number of other small things to do, all of which require time, and it will certainly render it too late in the season to think of taking men into the Field to encamp. . . . It is hard upon me to have this operation hanging over my head for another year, without any fault of mine; But with such a man as Ramsden there is no help for it.

"The experiments formerly made with the White Lights were perfectly satisfactory with regard to the use that we may derive from them, particularly in taking the angles across the Channel between Kent and Piccardie. I nevertheless think that it may be proper to try them once more between Shooter's Hill Tower and Nettlebed Windmill, a distance of about 47 miles, by reciprocal observations. This I took the liberty to mention to H.M. . . . Even the preparations for this sort of experiment require time. . . . I will supply you with the angles for pointing the Telescopes at Windsor on the two extreme objects; as it is not unlikely that H.M. may choose to look out from thence."

And here are two more letters addressed to Dr. Lind:—

From William Roy (to Dr. Lind at Windsor).

*Argyll Street, 8th March, 1787.*

I wish you would be so good as to supply me, as nearly as you can, with the distance between the center of the Devil's Tower (which henceforth I shall call the Maiden Tower) and the Flagstaff of the Castle. . . .

The object I have in view is to shew how nearly the longitudes of places may be determined by means of Ramsden's Instrument; and in the Duplicate of my Paper (which will be read this day at the R. Society) prepared for H.M. I mean to give an example of the computations of the Longitude of the Tower of Flagstaff from Greenwich. . . .

From William Roy (to Dr. Lind, Windsor).

*Argyll Street, 2nd July, 1787.*

Although, when one has, unfortunately, to do with such a man as Ramsden, it is altogether impossible to answer for what may happen;

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yet I hope we shall be able to try the Instrument in Hyde Park on Wednesday or Thursday next.

Perhaps H.M. may not like to have the Signal Staff on the Wardrobe Tower remain there for any length of time. If the Staff itself, Two Deals, and Four upright pieces are prepared, it may be put up any morning, and you can easily describe to the workmen entrusted with the execution in what manner they are to be joined together. . . . and if you are so good as to go up at that time you will be able to tell me how the trees on St. Anns Hill appear?

During the time of waiting, the selection of stations for the triangulation was completed and a diagram was submitted to the Royal Society In the spring of 1787, Sir Joseph Banks, President of that Society, communicated, through the Secretary of State, with the French Academy of Sciences, in order that the French geodesists might be ready to co-operate with the British in observing the rays crossing the Channel And all this time the necessary preparations were being completed for the erection of scaffolds and the showing of " white lights." The composition for these lights was burnt in a copper retainer. The light apparently did not last long.

The Duke of Richmond, Master-General of the Ordnance, gave every assistance, both in the preliminary operations and during the actual observations, by " furnishing an officer and a detachment of artillery-men for the work; ordering the laboratory at Woolwich to supply whatever fireworks might be wanted for signals; and temporary scaffolds to be erected at Greenwich Observatory, Shooter's Hill and Dover Castle, for the reception of the instrument."

In Roy's next letter there is an interesting reference to operations " westward of Windsor," showing that he always kept in mind, as the chief object in view, the triangulation of the whole country.

William Roy (To Dr. Lind, Windsor).

*Argyll Street, June 23rd, 1787.*

I always intended to apply to you for assistance, in any thing respecting the Signal proposed to be erected in the Center of the Platform of the Wardrobe Tower at Windsor. But I did not think it necessary to give any trouble of this sort, until we were just ready to begin.—At the instant that I write the Instrument is not finished. But Ramsden has been for some time past and at present is close at work upon it with every hand that he can employ. . . . I mean to adjust the line of collimation of the Transit Telescope, and see whether, by inversion to the Pole Star when it is stationary, it sweeps the vertical arches? . . .

When our observations have been made, the Staff, if H.M. shall please, may be removed; but the socket at Bottom should remain, as the point over which the Instrument is afterwards to be placed, when H.M. may please to order the operations to be continued to the westward of Windsor.

. . . You will no doubt come and see us at the Hampton end of the base where I mean to begin, and then I can show you our Flagstaffs.

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**Execution of the Triangulation.**—At length the instrument was finished, 35 months after it was ordered, and was placed on the 31st July, 1787, at the station at the end of the Hounslow Heath base, near Hampton Poor House. It was agreed that the British and French observers should meet about the 20th September. Between 31st July and that date the triangulation was pushed forward, working from the Heath south-eastwards and, before the meeting with the French, ten stations, as far as Wrotham Hill inclusive, had been observed from.

From William Roy to (Dr. Lind at Windsor).

*St. Ann's Hill, 17th August, 1787.*

It has blown so hard all day long and still continues to do so, that we have not been able to make any observation.

. . . If you please, one of the Lights may be fired about a quarter before 8 o'clock. As there is so small a prospect of calm weather I think it will be useless to throw away more of them. Our other Lights will be fired as I mentioned in my last.—But Artillery men's watches may probably (be) as bad as my friend Bisset's was on a former occasion.

The French representatives were three distinguished members of the Academy of Sciences, Comte de Cassini (the fourth Cassini), Mechain and Le Gendre. They arrived at Dover on the 23rd of September, and the two parties amicably settled the details of the operation. "A great number of white lights, fitted for long distances, and several reverberatory lamps had been previously provided." The French party, accompanied by Dr. Blagden, left for Calais on the 25th. The trigonometrical connection was successfully accomplished by the 17th of October.

It now only remained to complete the gap between the coast of Kent and Wrotham Hill. The season was getting late and Roy speaks feelingly of the tempestuous weather. "Perched on the tops of high steeples, such as Lydd and Tenterden, . . . . . we sufficiently experienced that operations of this sort, where the most important observations could only be made at night, by means of the white lights, should never be undertaken in the latter season." The use of luminous signals agrees with modern practice. Some difficulty was found in observing to them, for the lights did not burn for long and sometimes two would show up at the same time, "from the irregularity of the rates of the watches of the artillery-men." Two stations in the chain had to be left to the next season.

The distance covered was only some eighty miles, but the country was not particularly easy to triangulate. The chain of stations was: Hounslow Heath base, St. Ann's Hill, Hanger Hill, Norwood, Greenwich Observatory, Shooter's Hill, Botley Hill, Wrotham Hill, Hollingbourne, Frant, Goudhurst, Tenterden, Fairlight, Lydd, Romney base, Allington, Paddlesworth, Folkestone and Dover

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Castle. The distance between Greenwich and Dover is about 60 miles.

**Base in Romney Marsh.**—This base of verification was measured with Ramsden's hundred-feet steel chain in the autumn of 1787. Lieut. Fiddes of the Engineers was in charge of the work, and Roy says that "it was impossible for any person to fulfil the duties entrusted to him better than he did." Lieut. Bryce* of the Artillery, subsequently transferred to the Engineers, "an attentive officer and mathematician," was appointed to assist Lieut. Fiddes. We need not go into the details of this measurement. The base, as then measured, was 28,535·7 ft. long; as deduced from the Hounslow Heath base the value came out as 28,533·3 ft., a difference of 2·4 ft. or about 1 in 12,000. These values are given by Mudge. But Roy, in 1788, thought that the accordance was closer, for on the 7th February he writes to Dr. Lind :—

> It will give you pleasure to be informed that our trigonometrical operation answers to a wonderful degree of exactness. The base in Romney Marsh, between 28,000 and 29,000 feet, deduced from that on Hounslow Heath, agrees with the measurement within less than a foot.

The actual discrepancy found between the measured and calculated lengths of the base in Romney Marsh appears to be due, almost entirely, to errors in the measurement of this base. It is stated that there are reasons to suppose that it was not measured as accurately as the Hounslow Heath base. The latter, when tested by the definitive nineteenth-century triangulation, has only an error of $\frac{1}{188000}$, or 2 inches in 5 miles. Moreover, Roy's angles, as tested by the triangular errors of the 16 fully observed triangles, are wonderfully good, the mean triangular error, independent of sign, being just over one second.

The agreement between the distances across the Channel, derived from the English and French triangulations respectively, was good. Thus, taking the distance from the station at Dover Castle to the spire of Notre Dame at Calais, using only the Hounslow Heath base to compute from,

The English value was 137,449 feet.
The French ,, ,, 137,442 ,,

The derived difference of longitude, Greenwich–Paris, was 2° 19′ 51″.

No angles observed by Roy are incorporated in the Great Triangulation as reduced by Clarke; in fact, there is only one eighteenth-century set of angles included, namely, those observed by Mudge at St. Ann's Hill in 1792. But Roy's work deserves all

* Afterwards Sir A. Bryce, Inspector-General of Fortifications.

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praise. It was the first accurate triangulation carried out in this country and set a remarkably high standard ; it amply fulfilled its original scientific purpose ; it provided, for the first time, a thoroughly reliable framework for map making ; and it led directly to the formal founding of the Ordnance Survey.

**Isaac Dalby.**—Dalby was born in Gloucestershire in 1744, and after a struggling career, in which he always showed his preference for scientific occupations, he became, in 1751, mathematical master at the Naval School at Chelsea. In 1787 he was recommended by Ramsden to Roy. The latter, in describing the operations of that year, remarks, " it is proper that I should mention that Mr. Dalby, who had been recommended as an assistant, has acquitted himself throughout the whole perfectly to my satisfaction." In 1788 we find him making astronomical observations in the field. He contributed an addendum to Roy's *Account* of the Triangulation, which was published in *Philosophical Transactions* for 1790. He continued to be employed on the field work of the Survey until 1799. Captain Mudge writes, in the Introduction to Volume II of the *Account of the Trigonometrical Survey* : " I am to announce that Mr. Isaac Dalby, no longer able to endure the fatigues incident to the service, has retired from it ; and it would be a matter of injustice, if I were not to acknowledge the extent of his services, his unremitted labour, and attention."

Dalby was the author of a celebrated geodetic formula, known as Dalby's Theorem,* and was responsible for much of the mathematical work of the Survey in those early days. On leaving the Survey he became Professor of Mathematics at the Royal Military College, then at High Wycombe. He resigned this post in 1820 and died at Farnham in 1824. He was an original member of the Linnean Society.

**Roy's Last Days.**—Roy and his assistants completed the trigonometrical connection in 1788, and during the same year a considerable number of intersected and secondary points were observed in Kent and Middlesex, Roy having always in mind the mapping of the country. In his last paper he says, " the writer of this account cannot help considering it as being incumbent on him to recommend that the trigonometrical operation, so successfully begun, should certainly be continued, and gradually extended over the whole island. Compared with the greatness of the object, the annual

* If $\lambda, \lambda'$ be the latitudes of two points on the surface of a spheroid, $\omega$ their difference of longitude, $\alpha, \alpha'$ their reciprocal azimuths,

$$\tan \frac{\omega}{2} = \frac{\cos \frac{\lambda' - \lambda}{2}}{\sin \frac{\lambda' + \lambda}{2}} \cot \frac{\alpha' + \alpha}{2}.$$

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expence to the publick would be a mere trifle . . . The honour of the nation is concerned in having at least as good a map of this as there is of any other country."

In September, 1788, he returned to London in very indifferent health. In November, 1789, he went to Lisbon for the winter. In April, 1790, he returned to England and was engaged in correcting the proofs of his *Account of the Trigonometrical Operation* for *Philosophical Transactions*. He died suddenly in Argyll Street, in July, 1790, having corrected the proofs of all but the last three pages of this account.

During the later years of his life the fame he had won as a geodesist rather tended to eclipse his reputation as an antiquary; and on the whole we may be certain that, if a choice had to be made, this is what he himself would have wished. By the faithful, however, he was still rightly regarded as the leading authority on Roman Scotland."*

Soldier, geodesist, antiquary, the Ordnance Survey has every reason to be proud of its founder. And may all Survey officers aim at the same reputation!

* *General William Roy and his Military Antiquities, etc.*, by George Macdonald, C.B., F.B.A., LL.D. Society of Antiquaries of London, 1917.

(*To be continued*).

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# *SOME EXPERIMENTS ON THE VALUE OF SODIUM SILICATE IN CONCRETE WORK.*

*By* CAPTAIN J. C. P. TOSH, M.C., R.E.

IN the September issue of the *R.E. Journal* a Professional Note on the use of silicate of soda in concrete was published. Some experiments on the effect of sodium silicate on tensile specimens have since been made at the School of Military Engineering, Chatham.

All tensile tests were made on mortar briquettes consisting of one part of cement to three parts of Standard Leighton Buzzard sand by weight. It was considered that tests on mortar were of more practical value than tests on neat cement, since the silicate depends for its action, to some extent, on its penetration into the surface which, in the case of neat briquettes, would be very small.

The objects of the tests were to demonstrate the effects of sodium silicate on the strength of the briquettes and to see how the treatment could best be carried out. The results are shown on the subjoined table. Columns A and C give the strengths of ordinary briquettes cured in plain water and in a 5% solution of sodium silicate respectively; the latter show a marked increase in strength of about 35% at both ages. Column B shows the effect of adding the sodium silicate to the gauging water; this pronounced loss of strength is particularly unfortunate, as sodium silicate has the valuable property of increasing the rate of set of the cement. For example, a slow-setting cement taken from store was found to have an initial setting time of 270 minutes and a final setting time of 325 minutes; when gauged with a 5% solution of sodium silicate the initial setting time was reduced to 132 minutes and the final to 265 minutes.

The remaining columns show the effect of the silicate when applied under practical conditions. Columns D, E and F show the effect of 7 days' immersion in silicate solution, a method of application which could be used for concrete blocks and which has been common practice for some time in the manufacture of artificial stone. Columns G, H and I show the effect of dipping the blocks three times at 24-hour intervals in a 20% solution, a method analogous to that recommended for the treatment of roads and pavings where a 1–4 solution is sprayed over the surface. A strict comparison of the strengths given in the last six columns and those in column A is not possible, since the briquettes in the latter case were kept soaked in

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## TENSILE TESTS ON 1:3 MORTAR BRIQUETTES.

ULTIMATE STRENGTH IN LBS. PER SQUARE INCH (AVERAGE OF FOUR BRIQUETTES).

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| | Briquettes gauged with plain water and cured under water in usual manner. | Briquettes gauged with 7% soln. sod. silicate and cured under water. | Standard briquettes cured in 5% soln. sodium silicate. | Standard briquettes immersed for 7 days in 5% sod. sil. soln. and stored in damp sand when not immersed. | | | Standard briquettes dipped 3 times at 24-hour intervals in 20% sod. sil. soln. and stored in damp sand. | | |
| | | | | immersed for first week. | immersed for second week. | immersed for third week. | dipped during first week. | dipped during second week. | dipped during third week. |
| 7 days | 202 | 120 | 270 | | | | | | |
| 21 days | 301 | 190 | 419 | 323 | 368 | 350 | 321 | 342 | 359 |

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water for the whole 21 days, while the former had to be kept fairly dry to enable the silicate solution to be absorbed. It must also be borne in mind that the increased strengths obtained by the use of the silicate solution are due to its effect on only a small proportion of the cross-section of the briquette round its outer surface, and that the gain of strength of the surface portion is very much greater than the gain of the briquette as a whole. It will be noted that the effect of either of the two latter forms of treatment is much greater when carried out after the first seven days, and the figures tend to show that the sodium silicate may be advantageously applied to old concrete surfaces.

A few concrete blocks were also made and treated with sodium silicate solution, and, although no definite tests could be made on them, the difference between treated and untreated blocks was very marked; in the former there was no trace of laitance or dustiness on the surface and the arrises were much harder than in the latter.

We are indebted to Messrs. Brunner, Mond & Co., Ltd., of Northwich, for a supply of their P84 Grade of silicate of soda which was used in these tests.

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# *ANTI-AIRCRAFT METHODS IN VOGUE IN THE UNITED STATES ARMY.*

*By* Lt.-Col. D. M. F. Hoysted, d.s.o., R.E.

The general principles of Anti-Aircraft Defence must, perforce, be similar, to a great degree, in the Armies of the various Powers, but a description of some of the details of the equipment and training which have been evolved by another State may be interesting as throwing light on the national characteristics which vary the angle from which the problem is viewed.

In the United States Army very great importance is placed on the attack of hostile aircraft from the ground by artillery and machine-gun fire, and this tendency seems to point to the evolution of an automatic gun which may combine the advantages of both those weapons. For the reason that anti-aircraft artillery is not generally employed at fuze ranges below 4 seconds, it seems to have been felt that some improved type of weapon was necessary to supplement the gun. Great store was set on the machine-gun, owing to the reputation it gained in France, though its abilities at present are too limited to fill the gap efficiently. A heavier machine-gun has already been introduced and a one-pounder Pom-pom with a satisfactory fuze is in contemplation.

As in our service, the methods employed in the United States for combating an attack from the Air are grouped generally under two main heads—Active Defence and Passive or Moral Defence.

The means by which they are fulfilled are :—

1. (*a*) Aerial defence by offensive aircraft.
   (*b*) Ground defence by anti-aircraft artillery, machine-guns and searchlights.
2. (*a*) Aerial entanglements consisting of captive balloons, wire aprons, etc.
   (*b*) Camouflage by means of smoke-screens, false area representation, confusing lights, etc.

It is realized that passive defence alone is of no value against a determined enemy, and they admit that the most effective defence is obtained by the use of aircraft equipped with offensive weapons, provided that they can be concentrated at the right time and place, but this efficient concentration seems to be their difficulty, which has caused much more responsibility to be thrown upon the ground defence.

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In aerial warfare the time factor assumes even greater importance than in land or sea fighting, because of the speed at which aircraft can operate. The ground defence may have only four or five minutes at its disposal for its whole effort at any one station. The trend of experiment must therefore be in the direction of concentrating that effort, so as to obtain the maximum effect in the shortest possible time.

In the case of a high-flying enemy, the gun is the only ground weapon that is of any avail, but in the case of lower-flying craft, the practice, in the United States Army, is to make increasing use of the machine-gun. Their original machine-gun units were armed with a ·300-in. weapon, water-cooled and belt-fed, capable of firing 500 shots a minute to an effective anti-aircraft height of about 4,000 ft. The new weapon, however, is of a heavier type, though still water-cooled, as it was proved by experiment that an air-cooled gun cannot be kept sufficiently cool when firing more than a hundred rounds at a burst at the rate of over 500 a minute.

The ·500-calibre Browning weapon will entirely supplant for anti-aircraft use the lighter gun, which will be relegated to protective duties with organization of infantry or other arms. This heavier gun fires 550 shots a minute at a maximum anti-aircraft range of some 9,000 ft. and it is held that one hit in a vital part of the aeroplane at extreme range would incapacitate it.

The primary mission of anti-aircraft machine-gun units is to prevent the close-range bombing and machine-gunning of troop areas by low-flying hostile planes or "ground-strafing," as it was called during the latter period of the war. In the forward areas they are detailed to afford protection to trenches; strong points, and artillery positions, and in rear areas they assist in interfering with the bombing of the points they are told off to protect. A secondary mission is the protection of the anti-aircraft guns, searchlights and their necessary instruments from air attack, but great stress is placed on the primary mission, which should never be lost sight of. Just as anti-aircraft artillery is wasted if used for horizontal fire at a ground target, because the whole of the training of the unit has been devoted to effective fire on an aerial one, so the heavy machine-gun units of the United States A.A. Defence are not to be used for any but their legitimate purpose. This appears to have been entirely borne out by the records of the Army during the War. The 1st and 2nd Anti-Aircraft Machine-Gun Battalions, consisting of some 96 guns, during a period of two months in the front line, claim to have brought down 41 enemy planes, whereas only two planes are said to have been brought down by the remaining 1,500 machine-guns assigned to other units during the same period. Great stress is also laid upon the necessity of maintaining the M.G. Units intact, so that all their power should be concentrated on their primary

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and legitimate object. To break up trained Anti-Aircraft Machine-Gun Units for the defence of isolated places is regarded as disastrous.

The general proposal for A.A. Defence is that it should be possible to establish effective A.A. barriers as follows :—

1. Along the entire front of armies operating in the field.
2. Round such important cities, towns or strong points in the areas as are of limited extent, but which are of strategic, commercial or economic importance.
3. Locally, at important industrial sections of large cities, important isolated manufacturing plant, aerodromes, headquarters, supply and storage centres, bridges and other sensitive points.
4. For the local security of fortified areas on the sea coast.

(1) is termed the Front Line Defense (*sic*) Barrier.

(2, 3, 4) are termed Rear Barrier Rings.

The Front Line Defence Barrier consists of Active Defence methods only, while Passive Defences may be mingled with the active forces in the Rear Barrier Rings.

In the forward areas the defence is organized in belts which must needs conform to troop movements.

1. (Furthest from the enemy). A continuous belt of illumination along the entire front to be defended.
2. Gun Area.
3. Defence Aircraft Area.
4. Belt of mutually assisting A.A. Machine-gun positions at distances of between 500 and 1,500 yards from the front trenches.

A rear barrier ring is divided into similar belts, but in inverse order, and a passive one is interposed. In this ring mobility may be sacrificed to accuracy.

1. Continuous belt of illumination about the locality to be protected.
2. Gun Area.
3. Defence Aircraft Area.
4. Balloon and Kite entanglement area.
5. Belt of mutually covering Anti-Aircraft Machine-guns completely round the locality.

The machine-gun belt is *the innermost element*, so as to be able to deal with the raiders as they descend to bombing or strafing height. The pious wish is also expressed that the hostile plane should be kept under M.G. fire throughout the entire defence ring, and not only in the actual M.G. belt. This suggestion might not be heartily endorsed by the defending pilots.

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The general organization of the M.G. belt is the same as that of our Searchlight Units, the chain of responsibility and information descending from the headquarters of the higher formations, through battalion, company, platoon and section headquarters to the gun squad which consists of a Corporal and six men. The section is the smallest tactical unit of the organization, and consists of a Section Chief (N.C.O.) and two gun squads. A gun-emplacement is designed to consist of three parts, all of which are to be carefully camouflaged; the gun-emplacement proper, the ammunition supply trench and the belt-filling station about 50 yards in rear.

Considerable study is being given in the United States Army towards developing more efficient weapons for A.A. Defence. The greatest thinkers and the most daring experiments are striving to produce :—

(*a*) A gun with a very much increased rate of fire and higher muzzle velocity.
(*b*) A shell with a larger effective radius.
(*c*) A machine-gun with greater destructive power at a height of some 9,000 ft.
(*d*) A monostatic height-finder.
(*e*) An improved automatic fuze-setter.
(*f*) A clockwork or mechanical fuze.
(*g*) A quicker and more efficient data-collecting and computing machine and system.
(*h*) A practical and accurate sound-locator.

Below is a short description of the material in use at present :—

*Guns.*—Three A.A. guns were in use at the end of the war :—

(1) 3-in. gun, fixed pedestal, M.V. 2,600 f.s. Semi-automatic breech block, 360° traverse, 85° max. elevation, max. horizontal range, 12,750 yds.

(2) 75-mm. gun. Self-propelled truck, M.V. 1,800 f.s. Semi-automatic breech block, 240° traverse, elevation between 31° and 85°, max. horizontal range, 7,500 yds.

(3) 3-in. gun, trailer mounting to be drawn by self-propelled truck, M.V. 2,400 f.s. Semi-automatic breech block, 360° traverse, elevation between 10° and 85°, max. horizontal range, 8,000 yds.

The two latter were not as satisfactory as the first, owing to the poorness of the sighting, elevating and traversing mechanisms. Experiments, which were at once set forward, to find a light gun of about 75 mm. calibre (approx. 3-in.) and a heavier gun of about 105 mm. (approx. 4-in.), with a M.V. of about 3,000 f.s., yielded the following results which are in being :—

(4) 3-in. gun (with 15-lb. projectile) on self-propelled motor mounting, M.V. 2,600 f.s. Pneumatic loading, 360° traverse,

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elevation up to 80°, max. horizontal range, 17,800 yds., operated by either direct or indirect fire control.

(5) 4·7-in. gun (with 45-lb. projectile), self-propelled mounting, max. horizontal range 20,000 yds. Other details as for 3-in. gun, but with specially designed automatic fuze-setter fixed near loading-tray.

*Fuze-Setter.*—The principal component of the fuze-setter which produces the actual alteration of setting is very ingenious. It consists of a great number of insulated metallic strips laid on edge and compacted into a solid vertical plane or control block. There is one separate strip for each setting, and each strip has a different curvature corresponding to the variation in fuze-setting for various angles of elevation at each altitude. The terminals of the strips are brought out into a cable which extends to the altitude controller. In operation at any altitude, the particular strip for that altitude is not itself electrified, but the altitude controller functions so as to make all the strips on one side of that particular strip positive, and all the strips on the other side negative. The boundary between the positive and negative regions has then a definite shape and curve, so that a contact point carried by a slide on the arm (which is rigidly attached to the trunnion of the gun and varies with the elevation) will automatically follow the boundary between the positive and negative regions as the arm swings to different angles of elevation. The slide carrying the contact point is moved along the arm by a longitudinal screw which is driven through gearing by a pair of small electric motors. These motors rotate in one direction or the other according as the contact point touches a positive or negative region of the control block. The motors are thus controlled by the curvature of the controlling strip and, as they operate a parallel train of gearing which extends to the fuze-setter, they continually alter the fuze-setting to conform with the curvature of the guiding control strip.

*Height-Finder.*—Experiments are being carried out with a 4-metre inverted Image Folding Range-Finder and a 4-metre Stereoscopic Folding Range-Finder, both by Goertz and equipped with height-finding attachment. Also with the 2-metre Barr and Stroud Height-Finder.

*Fuze.*—The accuracy of a composition fuze for more or less horizontal use was brought to a great pitch of perfection during the war by our munition factories. But, for A.A. work, such a fuze suffers from the inherent defect that the composition burns at varying rates when the atmospheric pressure is subject to greater changes. The rate of burning is retarded at high altitudes or with a lower velocity of the projectile, and *vice versa*. The mean rate of burning decreases appreciably the greater the height of the target. The general advantage of composition fuzes is that they

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can be turned out much more quickly than other kinds in time of war.

A clockwork fuze is more regular and dependable for A.A. use It is independent of daily or periodic changes in atmospheric conditions, and need not deteriorate when stored in damp places, if properly constructed. Two or three different kinds are now under experiment in the United States, a German one driven by a spring in a similar manner to a watch, and another by a mechanism with centrifugal plungers combined with an escapement.

*Data-Computors*.—Those in use are much the same as in our Service, but the general feeling appears to be that electrical devices, as produced so far, are too delicate and unsuitable for the rough work of the field. They fail to give satisfactory results except in a few very favourable circumstances. The aim of such computors is to cut down the dead time of manœuvre, while the design of the gun should cut down the time of flight of the projectile. The more automatic such a device can be, the less chance there is of personal error creeping into the calculations, when the mind of each member of the personnel is intensely occupied with the work in hand, and subject to the irregularities of the nervous system of the individual. The chances of a hit are inversely proportional to the sum of this dead time of manœuvre and time of flight. For the greater this sum, the further ahead of the target must be the gun pointing when the shell is loosed, with the result that the hostile pilot has longer time in which to alter his height and direction, and thus nullify all the results of the computation. And although the data for fire must be most carefully prepared and continual preparation must be effected for each shot, the time interval between the shots must be reduced to a minimum.

The general conclusion that can be drawn from the foregoing account points to the fact that the United States Army is working on a slightly different line to ourselves. They are putting more of their effort into the ground defence.

It is interesting also to note that we appear to stand about halfway between the French and the Americans in this respect.

We are running true to form.

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# *THE ADVENTURES OF A BRIDGING TRAIN IN MESOPOTAMIA.*

*By* Major E. W. C. SANDES, D.S.O., M.C., R.E.

THE lecture delivered by Major F. V. B. Witts, C.B.E., D.S.O., M.C., R.E., on the 11th October, 1923, at the S.M.E., Chatham, on "Light Floating Bridges in Mesopotamia," has suggested that the experiences of the original Bridging Train with General Townshend's force may interest readers of the *R.E. Journal*. The history of this unit is one of initial success and final disaster. The tragedy of Kut is too well known to need repetition, and, to those who were involved therein, the memories of that tragedy and its aftermath are painful; but the victorious advance which preceded the disaster can be recalled with satisfaction, and even the retreat to Kut after the Battle of Ctesiphon had its compensations in the hard blows dealt to the pursuing Turks. My narrative tends unavoidably to be personal, and criticism is offered at times which I hope may be forgiven, yet without such criticism some points of technical interest may be lost and therefore it is included where necessary.

The Bridging Train of the 1st K.G.O. Sappers and Miners arrived in Mesopotamia from Roorkee early in 1915. It was placed under the command of Capt. M. G. G. Campbell, R.E., of the 3rd Sappers and Miners, and it then constructed a floating bridge across the Tigris at Kurna, some 48 miles above Basra. So small was the unit that never, from its first success to its final catastrophe, could it bridge the Tigris rapidly without assistance; and this assistance, however willing, was not always of the expert nature required for such very technical work. When I took command of the Bridging Train at Kurna in April, 1915, we totalled exactly two dozen men—1 B.O. (myself), 1 I.O. (Jemadar Sadar Din), and 22 Indian other ranks, including 1 Havildar. There was a fleet of 18 pontoons and a very elaborate equipment of stores, but no wagons or animals, as the country was flooded. Ten of the pontoons were of copper and the remainder of steel, some being of bi-partite pattern. We could thus make 95 yds. of light floating bridge, and, be it noted, the Tigris was nowhere less than 200 yds. wide and usually at least 250 yds. even at its lowest level. From this beginning grew the enormous bridging operations which developed later in Iraq.

The Bridging Train had 10 Weldon trestles, which were too heavy to find a secure footing in the slimy ooze of the lower Tigris, and

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these had to be discarded during the rapid advance on Baghdad in the autumn of 1915. In their stead I gradually accumulated a stock of small wooden trestles with plank ledgers, ranging in height from 1 ft. to 6 ft. (by rises of 6 in.) and of the simplest possible construction. These trestles were most satisfactory and enabled us to bridge the treacherous shallows of the Tigris with great rapidity. Only the heights from 3 ft. upwards required any strutting when in position. The trestles were stored in the barge or *mahela* (dhow) which held all the surplus gear and accompanied the unit. Every trestle had its height marked clearly on it, and even the largest could be carried rapidly along the bridge by eight men.

On the 19th April, 1915, when I took command of the Bridging Train, the British outpost force at Kurna was surrounded by swamps as far as the eye could see and was under observation by Turkish outposts entrenched on various islands. The climate was villainous and the insects almost unbearable. Our defended area was protected from the rising floods by dams, and pumping engines served to keep it moderately habitable. The troops lived in reed huts or tents, protected by walls of sandbags from the bullets of the Arab snipers, who crept up close at night, or the occasional shrapnel from the Turkish light artillery by day. Two Germans lived in a *mahela* anchored some miles upstream, and there they followed the peaceful avocations of beer-drinking and mine manufacture. Just before I arrived one of their mines floated down to the bridge and demolished part of it, so the first job was to make a boom across the river to protect the bridge and the ships below it. The river was then about 250 yds. wide, with a current of four knots in places. There was unlimited telegraph wire available, some 1-in. steel wire rope, a few barrels, and plenty of spars, planks and light cordage ; but no text-book gave any suggestions as to how such a boom should be designed or laid, and it was necessary that there should be a cut in it to allow large ships to pass when the force advanced. By good luck we hit upon a design in the form of a wire fence, 2 ft. 3 in. high, of four strands of wire or cable, supported by heavily-anchored barrel floats at intervals, laid diagonally across the river to collect mines only at the further shore, and plentifully supplied with a special form of spar float which kept the fence vertical everywhere.* The moral effect of this boom was so great that the Germans never sent another mine downstream.

General Townshend attacked from Kurna on the 31st May, 1915, and drove the Turks northwards beyond Amarah, and early in June the Bridging Train followed the 6th Division to Amarah, where it settled down for the summer. Very luckily it reached the place

* Details and diagrams of this boom are given in Appendix L of my book *In Kut and Captivity* (John Murray).

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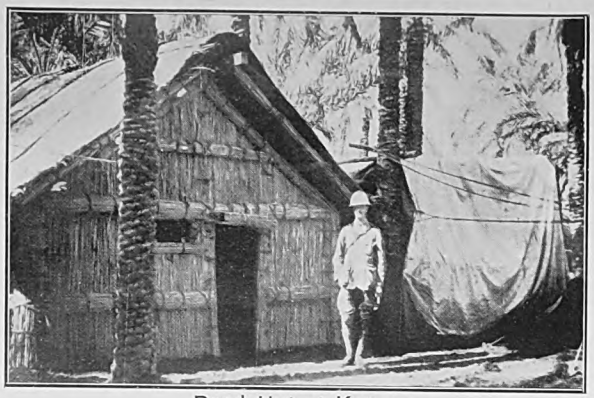
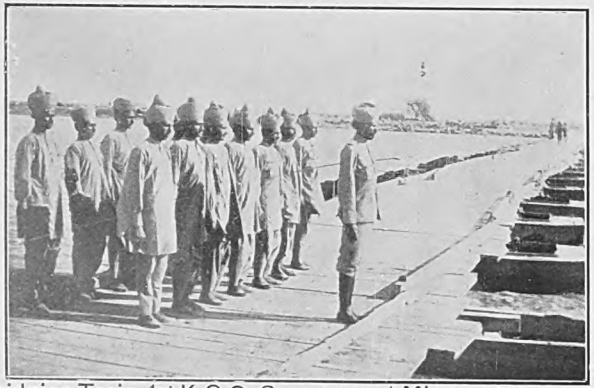
# THE ADVENTURES OF A BRIDGING TRAIN IN MESOPOTAMIA.



Reed Hut at Kurna.

Bridge at Kurna.



Bridging Train, 1st K.G.O. Sappers and Miners, at Amarah.

Arabs in covered Bazaar at Amarah.



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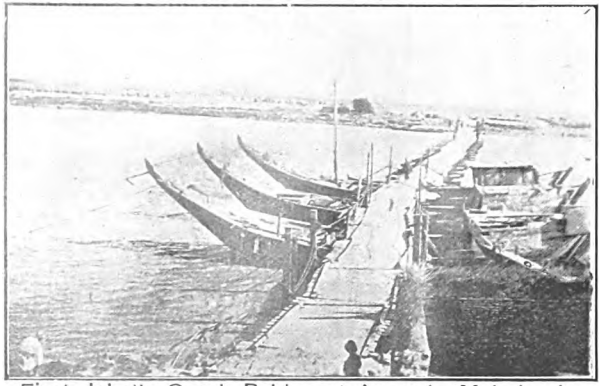
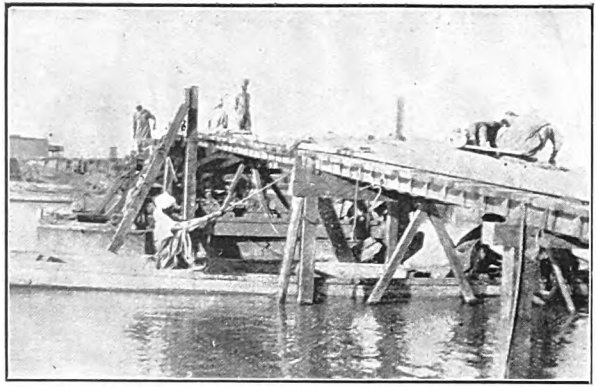


First Jahalla Creek Bridge at Amarah (Mahelas in foreground).



Trestles in Jahalla Creek Bridge at Amarah.

Old Arab Bridge at Amarah.

Bridge at Ali-al-Gharbi and Danacks.

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undamaged, for there were many hard bumps on the way. The pontoons, however, proved their strength, and at that time the unit had no Arab boats.

At Amarah we worked as hard as the extreme heat would allow. The hours were from 6 a.m. to 11 a.m. without a break, and again from 5.30 p.m. to 7.30 p.m. At 11 o'clock the glare off the water was so terrific that all the men had to wear spine-pads and dark glasses, and even then several were knocked out. They had a comfortable house near the Jahalla Creek and kept fairly fit if they could avoid damage from the sun.

The first work at Amarah was to bridge the Jahalla Creek to allow a column, which was rapidly approaching from Ahwaz, to cross into the town. This bridge took four days to make, as we had to use *mahelas*, naval cutters, and all the Weldon trestles, to supplement the 18 pontoons, but it was completed in the nick of time, and the very weary column found rest in the palm groves on our bank. When the last man had crossed the bridge the Weldon trestles looked as if they had been under heavy artillery fire, for some had sunk a good 2 ft., and others had tilted to alarming angles—and this in spite of extra ledgers and careful strutting. We quickly realized that these trestles were useless for rapid work on the lower Tigris and that a maximum possible length of floating bridge was what was required. It was decided to buy Arab *danacks* (paddling boats covered with bitumen) for use in the bridge, so Capt. Leachman, the Political Officer, sent messengers throughout the surrounding country requisitioning all large boats of that type, and offering a liberal rate of compensation. I found that no *danack* of under 6 ft. beam was of any use for a light military bridge, and, if possible, I refused any boat under 6 ft. 6 in. beam. The largest which arrived was 7 ft. 6 in. in beam. Each *danack* was rapidly fitted with a central structure to support a saddle, and in this work the Arab carpenters were invaluable, for, if well paid, they would work at high pressure all day and were very quick to understand what was required.

My Sappers picked up a lot of Arabic from the carpenters, and some were instructed in the difficult art of repairing damaged *danacks*. This work was mainly the application of hot bitumen (Arabic, *jir*) to cracks in the bitumen skin of the *danack* by first heating the *jir* in a pot, and also the skin around the crack, and then applying the stuff with a rolling-pin. The bitumen had to be heated to exactly the right consistency or else it would not stick. My "Jir-Wallah" Sappers were so proud of their newly-acquired art that they earned the name of "Arabi Log," and used to talk Arabic at times to support their new rôle. Without their aid the boats could never have survived the wear and tear of the advance.

After the completion of the first Jahalla Creek bridge we had to

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replace all the pontoons, Weldon trestles and *mahelas* in that bridge by Arab *danacks* and to manufacture the necessary baulks and chesses for a new roadway more than 200 yds. long. The men worked with a will, and, with the assistance of the Arab carpenters, a *danack* bridge had been completed by the end of June, 1915, and all the pontoon equipment removed. We next threw a pontoon bridge across the Tigris north of the existing Arab bridge opposite the centre of the town, and then proceeded to remodel the latter bridge. This crazy structure, which had no approaches or ramps for vehicles, was made of Arab *gissaras*—large bitumen-covered pontoons with gunwales 5 ft. above the water—carrying an unstiffened roadway of rubbishy spars and remnants of planking. It had to be altered to take vehicular traffic, including field-guns, and thus needed a new stiffened roadway with railings, a proper swinging cut and new ramps; in fact, a new bridge had to be built, except that it was possible to use the old pontoons. This was a big job and occupied the unit throughout the scorching heat of July, while the *danacks* for the advance were being steadily collected and fitted with saddles by the Arab carpenters.

Amarah having been connected to the mainland in both directions by good bridges of local manufacture, the Bridging Train was ordered to prepare for an advance northwards. The beginning of August, 1915, saw the unit hard at work completing an auxiliary Bridging Train of *danacks* to supplement the 18 pontoons, and, by the middle of the month, it was ready to advance with 30 rafts fully equipped and sufficient for 305 yds. of floating bridge. Gradually, during the advance and retreat, most of the rafts were lost; but, aided by remarkable luck, the little Bridging Train always managed, somehow, to span the river when ordered to do so.

After the middle of August we began to leave Amarah for Ali-al-Gharbi, which General Delamain had occupied with the 16th Brigade as an advanced post. Early in September all the rafts had arrived at this place, where a bridge was made, and we settled down till the 6th Division had passed and had camped at Sannaiyat, preparatory to an attack on the Es-Sin position of the Turks below Kut. I did not enjoy the stay at Ali-al-Gharbi. The heat was atrocious, we were bitten to pieces by sandflies at night, and had no guard whatever, though on the borders of a town swarming with treacherous Arabs who could have rushed the bridge at night and cleared off before help could arrive. It was not the time, however, to demand protection, as every available man was being sent up to the front, and the few infantry a mile below the bridge were required there to protect the shipping.

The Arabs were most expert thieves. We had bought two excellent *danacks* at Amarah, which were sent up to Ali-al-Gharbi. The former owners followed them to that place, stole them at night

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from under the rifles of a small guard, obliterated all marks, took them back by night to Amarah, and, I believe, re-sold them to the detachment at that place, as a couple of boats exactly like them reached me later as reinforcements. One cannot but admire such enterprise!

On the 20th September, 1915, the Bridging Train reached Sannaiyat, and bridged the Tigris, which was then 275 yds. wide at that place. Five days later it moved up five miles to Nakhailat, near the Chahela Mounds, and again bridged the river preparatory to General Townshend's attack on the Es-Sin position. This was a difficult spot, as the river curved sharply and the high banks were treacherous, but the bridge was only about 200 yds. long, so that the best boats could be selected. The R.N. Air Service arrived before us and occupied the only possible bridge site on the left bank where their sea-planes rested on a sandy beach. They refused to budge, so we then proceeded to debate the point. It turned out that they wanted planks to launch their machines, while I wanted a right of way through those machines. *I bought that passage for 20 planks.* The bridge was ready in five hours, but the white wings on all sides terrified the transport mules and ponies crossing the bridge, and luckily they were soon removed elsewhere.

General Townshend attacked the Turks at Es-Sin on the 28th September, 1915, and the next day the enemy was in full retreat north of Kut, which the 6th Division then occupied. The battle took place in rolling clouds of dust. The British victory depended largely on the success of General Townshend's feint on the right bank on the 27th, followed by the transfer of his maximum force to the left bank for an encircling movement on the 28th. The bridge was thus all-important. Practically the whole of the Division crossed without a check in $5\frac{1}{2}$ hours during the evening of the 27th, and unknown to the Turks. I found, subsequently, that a Brigade with first-line transport took about $1\frac{1}{2}$ hours to cross.

It was important to have due notice of the approach of troops at any time, so we made a single-spar portable observation post with wire-rope guys and a chair on top, and erected it about 150 yds. upstream of the bridge. On this perch I roosted for many hours, and could generally detect the approach of troops in spite of the haze. After the battle the Bridging Train was left behind and accumulated much wealth. All sorts of flotsam and jetsam came down the river, and we had eagle eyes. We got a first-class dinghy (most useful for soundings), two *bellums* with ornamental brass fittings which were flattering to our dignity, and sundry barrels, planks, pickets and large beams of wood. The letters *B.T.* were hurriedly painted on the new boats in case of subsequent dispute, but I knew we were fully justified in retrieving all abandoned craft and material for later operations.

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The pursuit of the fleeing Turks was pushed as far as Aziziah, though with little success beyond the capture of Kut-el-Amarah, and we were then towed through the Es-Sin position and past Magasis till we reached Kut and moored along the right bank at Woolpress Village (liquorice factory) opposite the town. There we re-organized, repaired boats, sorted stores and awaited the order to follow the Division to Aziziah. Again there was no guard, though the rafts stretched more than a quarter of a mile along the bank. After a few days we moved on once more, but unfortunately the rafts had to be towed, mostly by large river steamers, as these became available, and consequently we reached Aziziah piece-meal. Some tows of rafts took nearly a week to make the voyage of about 90 miles, as the river was full of shoals.

On my arrival at Aziziah, in the middle of October, with some of the earliest tows of rafts, I found General Townshend in a defended perimeter camp on the left bank with no means of access in force to the right bank, and in touch with the Turkish outposts at El Kutuniah close upstream, whence the enemy could easily advance down the right bank and cut the river line of communication below Aziziah. It was imperative that the river should be bridged immediately, and half of the Bridging Train, including almost all the pontoons, had not arrived. Though the river was 280 yds. wide, we started gaily out from the left bank and hoped for the best. With extreme difficulty a single plank bridge was completed in two days, and a battalion crossed it safely in an hour. I wish there was a photograph of that bridge. It began with *danacks* near the left bank, continued with Wheatley bag rafts, barrel rafts, *bellums*, naval cutters and one pontoon placed broadside to the current to gain length, and it finished with a lot of small trestles which sank gradually in the ooze and tilted to all angles. The current in places ran at 5 knots. I was given *carte blanche* by the G.O.C. to prowl around the shipping and commandeer every *bellum*, private or otherwise, to which I took a fancy. I did so, and an avalanche of furious owners descended on my head within a couple of hours; but by that time the requisitioned boats were well—*very* well—lashed and anchored in the fantastic bridge, and the owners departed with imprecations. As the other tows of rafts arrived from downstream, the bridge was improved and completed, but it was as well that the purloined boats were never returned, for everything that could float was wanted during the later operations.

The 11th November, 1915, was the day on which the unfortunate 6th Division began the final advance on Baghdad from Aziziah. The 18th Brigade occupied El Kutuniah a few miles upstream and the Bridging Train followed on the 16th November. The unit was at last given a fleet of six launches, and the spare gear was transferred from a *mahela* to a small steel barge, in which I lived thereafter with

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most of the men. The course of the river above Aziziah was very tortuous and the current so rapid in places that a launch could scarcely make any headway with more than six rafts; but, by sending my heaviest tow in the van and following in rear with the barge, I could keep the flotilla concentrated to about ¾ mile in length and maintained control by an improvised system of flag signals. Directly any launch grounded all the other launches stopped, and the two nearest anchored their tows of rafts and assisted in hauling the delinquent off the sandbank.

At El Kutuniah we completed a 250-yd. bridge between 5 p.m. and 10 p.m., assisted by a section of the 3rd Sappers and Miners, and General Nixon (the Army Commander) inspected it on the 17th November. He was much surprised that there were only 18 pontoons and ordered a telegram to India demanding 50 more pontoons at once. Possibly other Bridging Trains benefited by this order, though it was too late to be of use to us. The next day we dismantled the El Kutuniah bridge and formed up along the right bank preparatory to an advance; but at 7.30 p.m., just as the men had finished and had turned in dead-tired, an urgent order came to bridge the river again, and by 11 p.m. we reached the left bank once more. This was our best piece of work—a 250-yd. bridge completed in the dark in 3½ hours, when the men were already tired.

On the night of the 19th/20th November the Bridging Train followed General Townshend to Zeur and a bridge was made in the morning to allow a detached brigade on the right bank to cross again to the left bank and follow the main body to Lajj, near the Ctesiphon position of the Turks. Our luck held, for we managed to complete the Zeur bridge without mishap, but there were only *two* rafts of decrepit *danacks* in hand when the river had been spanned. Directly the brigade had crossed the bridge was dismantled and formed up into tows, and the flotilla was under way again after 11 hours of continuous labour. So fantastic a loop of the Tigris occurs above Zeur that 5 hours of steaming brought us back to a spot within half a mile of that place. This will give some idea of the complications of an advance or retreat by the river.

It was on the 21st November that the launches puffed and fought their way against a rapid current to Lajj, where the ships of the main body were already moored for over a mile along the left bank and the troops were just about to move out to their positions of assembly for the Battle of Ctesiphon. The Bridging Train got to work at once and a bridge was completed by the evening. It was a very difficult site. The left bank was steep and 25 ft. high, the current near it ran at 5 knots, ships were crowded close above and below the site, and the bottom was of hard and slippery clay in which anchors failed to hold unless kedged. Early on the 22nd November, while the din of the battle was incessant, I was ordered,

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greatly to my surprise, to dismantle the bridge. We set to work, and at the very moment that the last raft had been taken out and the last anchor raised we were told to re-erect the bridge. It was heart-breaking. At last, at 8 p.m. the bridge was there once more, and the men got some food and rest.

The next day we dismantled again, but at 8.30 p.m. on the 25th, when the battle was over, we were ordered to bridge the river again at once. This we did and reached the well-known right bank for the third time as dawn broke on the 26th. No reason was ever given for these orders, though, doubtless, there was a good one in each case. On the 27th November General Townshend ordered a retreat southwards, and at 2 p.m. I was told to dismantle the bridge and be gone at all costs *by* 4 *p.m.*, abandoning boats if necessary. It seemed impossible to avoid losing many boats if we were to get away in two hours; but we were determined that, come what might, we would not abandon our boats, for this would have been disastrous to any further offensive operations on the right bank. The men worked like furies, we cut most of the anchor cables close up to the anchors, tumbled the spare gear anyhow into the barge, and on the stroke of four o'clock were dashing downstream in the wake of the other shipping, though with only four launches instead of six. Two launches had been taken for other work and the remaining four were sadly overloaded.

Along the heights on the left bank sat lines of Arabs, with rifles partly concealed under their clothes, longing to open fire but not daring to do so while the retreating British infantry were near. They had their innings later, when the wide bends of the river sent us out into the country to the west. The launches kept at full-speed, regardless of risk, and the Indian *Serangs* in charge of them had to guess the positions of the channels as best they could. They made no mistake till nightfall, when one launch ran down a back-water and piled herself and her rafts on a sandbank. The whole unit stopped and worked till near dawn in a vain endeavour to extricate the culprit, but without success, and I had then to make the unpleasant decision as to whether to abandon the offending launch with her rafts and crew or to leave General Townshend without a bridge at Aziziah where he had arrived. Rightly, as it turned out, we abandoned the launch and rafts, having first seen that the Royal Navy (as represented by one armed tug) had observed their plight. Directly we reached Aziziah a bridge was ordered, and, as it neared completion in the evening, the abandoned launch and rafts hove in sight upstream and soon enabled us to complete it. Again the luck of the Bridging Train had held.

At Aziziah on the 30th November urgent orders arrived again that the unit was to get away with the utmost speed and that nothing must be allowed to delay its departure. Many of the

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*danacks* were now leaking badly, so we left those till the last and then sank them when there was no more time for work. General Townshend had halted his main body at Ummal-Tabul, a few miles below Aziziah, and there the Bridging Train moored for the night, under the high left bank and upstream of the large ships.

On the 1st December the successful rearguard action at Ummal-Tabul was fought. The British force checked the pursuing Turks and then continued the retreat towards Kut. My orders overnight had been that I was not to sail in the morning till all the other shipping had gone; but at daybreak a violent action developed and the large ships were so slow in getting off that the Bridging Train was being raked with shrapnel and several rafts were sunk. We hung on till only one tug with an ammunition barge remained below us, and then left without orders, as we were in imminent danger of capture by advancing Turkish infantry, under whose rifle fire we then were. Meanwhile, the British force on land was retiring in echelon of brigades inflicting heavy loss on the enemy with accurate gun-fire.

No orders for the Bridging Train were available, so it steamed its best and took its chances. The rafts narrowly escaped disaster by collision with the stranded and burning steamer *Comet* and the disabled gunboat *Firefly*, both of which were soon abandoned and were captured by the enemy. All that afternoon we steamed hard, running aground frequently, helping stranded ships at times, and being sniped from the right bank whenever a bend took us to the west. At last after dark all the launches, and the barge also, were aground somewhere in an impossible reach, so I ordered a halt till dawn, when the unit could perhaps concentrate if it had not been captured. As day began to break we were off once more, but were rapidly left behind by the fast river steamers and their only remaining escort, the armed tug *Sumana*. The sweeping bends of the Tigris prevented us from keeping pace with the retreating troops. On the left bank were many Indian stragglers, mostly camp-followers, who plodded aimlessly and wearily along or lay down exhausted to meet their fate. It was impossible to stop repeatedly to rescue all these men, nor had we space for them, but a good few found room in the launches. It seemed more than doubtful if the Bridging Train would get through even if the launches kept at full speed and the *Serangs* guessed the right channel every time.

About midday, when the launches were still some miles above Shumran, Arab cavalry pursued them along the right bank, rapidly overhauling them and firing on them from the saddle. The men on the rafts and launches returned the fire and emptied a saddle or two, but the *Serang* of the launch towing all the valuable pontoons left his wheel and the launch ran into the bank. Though she slid off unharmed, two rafts astern of her capsized and a *lascar* on the launch is believed to have then cut the towing ropes. Anyhow, the

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pontoons went adrift and the Arabs were on to them in a trice, while the remaining launches with their cumbrous tows were whirled downstream by the rapid current. Thus the unit lost all its valuable pontoons almost within sight of Kut—a disastrous day, indeed. The British rearguard on land, hearing the fusillade on the river, sent some artillery to the bank and later provided a cavalry escort to assist us past Shumran, so that at last we reached Kut, though with only 12 *danack* rafts out of the 30 pontoon or *danack* rafts with which we had advanced from Aziziah just 17 days before. Many of these 24 remaining boats were sinking, as they were moored along the river front of the town.

Reinforced by many *danacks*, collected at Kut during the advance on Ctesiphon, the Bridging Train was able to recoup some of its losses, though the new boats were too small and were leaking badly. I think that the original demands at Amarah had cleared the country of all really satisfactory craft. However, on the 5th December, when all the large ships had sailed for Amarah, General Townshend ordered a bridge to be made to enable the 6th Cavalry Brigade to escape to Ali-al-Gharbi. This bridge was duly completed by the next morning and the whole brigade crossed unhindered. There were only sufficient boats to reach a sandbank on the right bank opposite the Fort—the narrowest part of the river—and most of the *danacks* were leaking to such an extent that I had to have a man in each boat to stop the jets of water with lumps of clay whenever a field gun and team crossed the bridge. Under such a load each new *danack* sank till its gunwale was just two inches above water. Not a shot was fired by the Turks during the crossing, not a ripple disturbed the water, not a baulk broke, and not a boat sank, which was fortunate as *there was not a single spare boat.* The sandbank, though apparently hard, suddenly became a quicksand while the bridge was fully loaded with traffic. All traffic had then to be halted on the bridge, and had to remain there till a causeway of small trestles, baulks and chesses could be made across the sandbank and so to the actual shore. For over an hour the bridge, crowded with men, horses, mules, wagons and carts, and with several boats sinking slowly, in spite of desperate bailing and plugging, was an ideal target for any Turkish field-gun, yet not a gun spoke. A few well-placed rounds would have sealed the fate of the bridge and consequently of the brigade. Shortly after the brigade had gone two *danacks* foundered hopelessly; and while the bridge was being dismantled it was attacked by Turkish and Arab infantry and work had to cease till after dark. Never was there a greater piece of luck than the escape of the 6th Cavalry Brigade from Kut.

The men worked all night at dismantling this bridge. When the job was nearing completion in the early dawn, an order arrived that another bridge was wanted at once, for tactical reasons, nearer

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to Kut town. With great difficulty the new bridge was finished on the evening of the 8th December. For this bridge it was necessary to use a number of the old Arab *gissaras* from a dismantled Arab bridge brought up previously from below the Fort, and to stiffen these boats with large beams. The bridge had to be made on a bend of the river where the current ran diagonally, and a cut was impossible. The roadway was of the flimsiest description in places, and altogether the structure was depressing in appearance, though I think it would have supported field guns if man-handled across. I presume that the purpose of this bridge was to enable the 6th Division and 30th Brigade to leave Kut even as late as the 9th December if occasion required; but on that day the Turks attacked the bridge with a brigade on the right bank, overwhelmed the small covering party and captured the bridgehead. The Bridging Train lay out all day on the left bank with a few infantry and prevented the enemy from crossing the river. After dark Lieut. A. B. Matthews, R.E., and a party of volunteers from the 3rd Sappers and Miners, accompanied by Lieut. Sweet of the Gurkhas and a squad of his men armed with *kukris* to cut the anchor cables, arrived with charges of gun-cotton between planks in order to demolish the bridge, which had now become a menace to the safety of Kut. The demolition was most gallantly and successfully carried out under the noses of the enemy, who were quite unaware of what was happening till the charges exploded. The bridge, which was cut in two places, and part of which was already sinking, broke into sections still held by a few anchors, and the remaining boats gradually sank in the next few days. The launches alongside the bridge were unable to steam past the enemy to Kut, though they made several attempts, so they had to be abandoned and sank gradually in the mud of the bank till they had disappeared altogether in about three months.

Thus ended the active operations of the Bridging Train, 1st K.G.O. Sappers and Miners, in Mesopotamia. It was a lamentable ending, but inevitable. The unit might have been sent downstream with the shipping before Kut was surrounded, but that would have bound General Townshend to operations on the left bank only, and probably to a passive defence. He has stated in his book that he contemplated an active defence, using the bridge to transfer his striking force from bank to bank, but the question must arise as to how long it was likely that the Turkish artillery would allow the bridge to exist. As it turned out, the Bridging Train was sacrificed to save the 6th Cavalry Brigade, and doubtless the exchange was sound. If Kut had been relieved, the unit might possibly have assisted in the river-crossing by means of flying bridges at one or two points. Beyond that, and perhaps the construction of a trestle bridge across the Shatt-al-Hai channel, the Bridging Train was powerless after the 9th December, for all hope of a floating bridge across the Tigris was then at an end.

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During the siege we were first occupied on odd jobs in and near the town, and later in preparing bridging material to co-operate with the Relief Force, such as *mahela* rafts for a couple of flying bridges across the river, and trestles, baulks and decking for a Shatt-al-Hai bridge. This decking was made from the strong front doors of Arab houses, fastened together with dogs made from verandah railings. Over 200 doors were collected in the R.E. Field Park in Kut for this purpose. A test proved that they would stand the wear and tear of occasional field artillery traffic. I do not suppose that so expensive a decking has ever before been contemplated for a temporary bridge.

When the surrender came and the Arabs could retrieve their unused doors, the scene in the Field Park in Kut almost defies description. Around a huge bonfire of new manilla cordage, baulks, planks, trestles and a theodolite or two, which I made on the 29th April, 1916, the Arabs danced and screamed and fought for their doors, while the air was rent with the detonations of the gun-cotton charges which were destroying our guns and howitzers as the Turks marched in. The Bridging Train vanished into distant Anatolia, and many of the men never re-appeared. They had done their bit in the war, nevertheless, for they had made altogether 17 bridges across the Tigris in 9 months, and 7 out of that total were made during 13 days in November, 1915. They worked like Trojans, they were cheery, even in the most dire adversity and distress, and they were loyal to the end. In fact, they lived up to the traditions of their Corps.

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My account of the adventures of the earliest Bridging Train in Mesopotamia may, perhaps, be supplemented by a few remarks on the equipment and methods of work of that unit. If, in any of these remarks, I draw attention to points in which the equipment of the unit was unsuited to the conditions, it should be remembered that that equipment was hardly designed for a gigantic river such as the Tigris, and that the exigencies of the service in other theatres of the war prevented all our demands from being met. Both the men and the equipment of the little unit in Mesopotamia were excellent in quality, and the deficiency was chiefly in quantity.

Throughout the rapid advance we longed for a Barr and Stroud range-finder with which to fix the *exact* width of the river at any point. The pontoons formed only a portion of any bridge, and had always to be used for the swinging cut or where the current was very rapid, the remainder of the bridge being formed of *danacks* or *bellums*. The *danack* is a species of flimsy gondola, made, apparently, of matchwood and rubbish coated with bitumen; and the *bellum* is a paddling boat of inferior planking. One soon got to know the most reliable *danacks*, and it was necessary to use these in the more

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difficult parts of the bridge and to employ the inferior boats as little as possible and only in slack water. With an exact and early estimate of the number of 5-yd. spans required for the bridge, it would have been possible to detail the boats at once for use in its sections of varying difficulty, sending them out to the bridgehead in the correct order according to the numbers painted on their bows and sterns.

The copper pontoons were more satisfactory than the steel ones. The paint soon got rubbed off the latter and rust appeared. There was no time to re-paint any pontoons during the advance or retreat. The copper pontoons rarely leaked, and withstood many hard bumps when being towed behind large river steamers.

The chesses of the standard equipment were of finely-planed teak and very durable. They had the disadvantage, however, that in stormy weather, when they were wet, they became so slippery that no horses, and few men, could maintain a foothold on them while the pontoons were pitching. In the improvised equipment made in Mesopotamia we used pine or deal chesses, made from unplaned planks. These did not last nearly so long as the teak chesses, but gave a better foothold and were lighter to carry—an important point with tired men.

The baulks of the regular equipment were beautifully finished, tapered longitudinally, and of girder section. With the whole personnel fully trained, they would probably have given complete satisfaction. Unfortunately, we did not always have the assistance of Sappers, and the baulks were often fitted incorrectly in the saddles. They then tilted sideways and broke. We reverted to a more primitive type of baulk of ordinary rectangular cross-section, guaranteed to stand rougher usage, if rather heavier, and these gave good service.

The usual pattern of anchor generally failed to hold securely in the greasy clay of the river bottom, so the grapnel type used by the Arabs was adopted. The bottom, however, varied so much that we never knew whether an anchor dropped three days before could be recovered. It was often buried several feet deep in the clay by that time, and so few men were available that it was impossible to spare any for raising several anchors every day. Many anchors were recovered, which no amount of ordinary hauling would budge, by the use of tackle attached to the anchor cable after the cable had been passed over the bow of a pontoon, one block being attached to the cable and the other made fast inside the stern of the pontoon. Six men then seated themselves in the stern and hauled in unison, thus giving a regular and gentle pitching motion to the pontoon, whose loaded stern acted as a lever, with the bows as fulcrum. I can imagine the gasp of horror of the pontoon manufacturer who reads this, but experiment showed that a pontoon of the type with us

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suffered no damage from such usage, and many anchors were thus recovered after 10 to 20 minutes of " rocking and heaving " which would otherwise have been lost.

Throughout the advance on Baghdad the unit was much hampered by the lack of accurate large-scale maps of the Tigris, though such maps would have needed constant revision, owing to the rapidly changing direction of the currents.

In the earlier operations, river transport was so deficient that the rafts had always to be towed astern of large river-steamers, and the unit was lucky not to lose its pontoons in consequence. Often the towing-steamer bumped into the bank at a good five knots, slid off, regained speed, and caused the towed rafts to attempt an overland journey before they could regain their native element. Desperate fending off by the Sappers on the rafts alone prevented a disaster. When going downstream, a large steamer, towing rafts, often took the wrong channel and ran aground. Immediately she would be encircled by heaving and grinding rafts and shouting men. Our excellent pontoons stood this buffeting in a marvellous way, but we lost many a useful *danack* and *bellum* raft through such collisions. The truth is that, for towing a Bridging Train on the Tigris, a special form of fast launch of not more than 2 ft. 6 in. draught is required. For the final dash on Baghdad from Aziziah we were given six Bombay harbour launches of 4 ft. 6 in. draught when loaded. There were altogether at that time 9 pontoon rafts and 21 *danack* or *bellum* rafts—sufficient for about 305 yds. of light floating bridge. Five launches towed 6 rafts each, and the sixth towed the barge. But the 4 ft. 6 in. draught of the launches was far too great and they were always grounding. Every raft was cross-braced for towing with $\frac{5}{8}$-in. steel-wire rope, if enough was available.

The demands of the Bridging Train in cordage, wire rope, and timber were insatiable, and its efficiency was considered so important that I was given first call upon all material arriving in the Field Park during and before the advance. For anchor cables, 3-in. manilla cordage was in great demand, though sometimes $4\frac{1}{2}$-in cordage was used for important anchors. A coil of 6-in. cordage, forming part of the regular equipment, was soon left behind as unsuitable and unwieldy. For light lashings we used a considerable length of 1-in. manilla cordage ; but we swallowed the 3-in. cordage as quickly as it arrived and could never get enough. As regards steel wire rope, the unit used a quantity of 1-in. or $\frac{5}{8}$-in. circumference for operating the swinging cut, and a still greater amount of $\frac{5}{8}$-in. size for horizontal cross-bracing throughout the swinging cut, and sometimes for rafts when being towed. We had a coil of 3-in. wire rope, but left it at Amarah, as there seemed no prospect of its use.

The lack of mauls for driving pickets caused much trouble. The few excellent mauls in the regular equipment wore out in time or were lost, and there was no hard wood for the manufacture of

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new ones. In all spare moments our carpenters were making mauls of the only wood obtainable, and binding them with wire, but the supply could not keep pace with the demand. In the retreat from Ctesiphon we were reduced to using sledge-hammers which were disastrous to the pickets.

The supply of carpenters was never sufficient to cope with the work, unless the unit was at some large town where good Arab carpenters could be hired. By far the greater part of the work was carpentry. My letters to Headquarters in India were full of supplications for carpenters and still more carpenters, but our life as a unit was too short for these requests to have full effect.

As I have already mentioned, the Bridging Train had to be assisted by other units if rapid work was essential. Usually we were lucky enough to have the help of half a company or one section of the 3rd Sappers and Miners, attached to us for a short time, but the men were frequently changed. Sometimes Pioneers were substituted for the Sappers. The new men, whoever they might be, did not know our methods of work and had not had the experience on the river necessary to make them expert watermen. My own Sappers had become very skilful in handling boats in a rapid current when the final advance started, and consequently I had to keep them almost entirely for anchor-laying during rapid work, for the speed of construction depended mainly on the rapidity with which the anchors could be laid. Rowing in the pontoons for hours at a stretch was very exhausting, though the splendid physique of the men stood the strain well.

In conclusion, a short description of our system of swinging cut may be of interest. The cut was usually fairly near one bank, though its position was governed, of course, by the main channel. A cut of 200 ft. width was usual, with 14 pontoons in the swinging portion, and this sufficed to pass a river steamer of the " P " Class with a steel barge on each side. About 18 men were required to operate the type of cut used by us, if speed of opening and closing was essential. A squad of that strength opened the cut complete in two minutes in fine weather, working at the double ; and they closed it and joined up the roadway in four minutes by the watch. A squad of 10 men, however, could open or close the cut slowly. I admit that this type of cut could not be used in very rough weather, as the strain on the anchors holding the 14 pontoons when the cut was open would then be too great, and they would drag. But during the fairly calm weather of the advance and retreat in 1915 this cut was most successful.

Referring to the diagram, it will be seen that the point P is the pivot of swing, and the anchor cable PD is laid at a very slight angle to the direction of the current, so that it tends to swing pontoon P clear of pontoon A when the cut begins to open. The amount of this clearance is controlled by ropes between these two pontoons.

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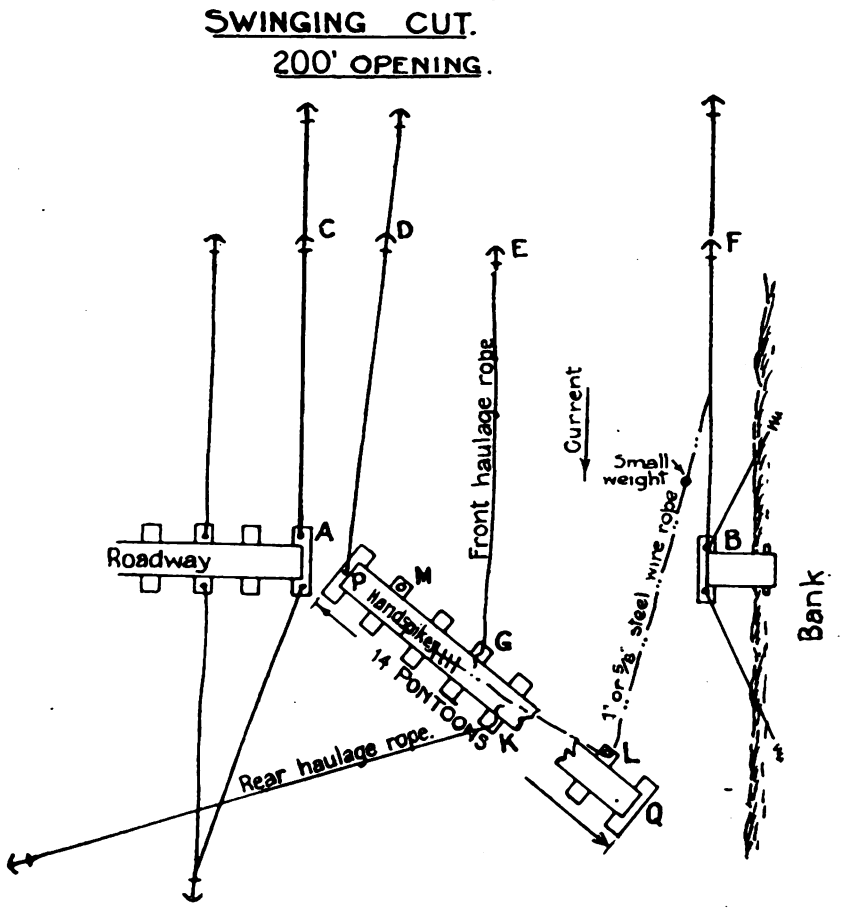
The steel wire cable for the haulage of the cut is attached to the anchor cable FB, runs through a block at L, and has 4 handspikes attached to its end. There is a snatch block at M. To close the cut, the handspikes are manned by a team of 8 men who march along the cut from L towards M. On arrival at M, when the cut is about




half closed, the team turns about and marches back towards L, and, as they turn at M, a man slips the haulage cable into the snatchblock on that pontoon so that the tension continues. Two men assist by hauling on the rope EG, and make it fast later at the centre of the swinging portion. Four men are posted at A, and two at B. The whole swinging portion is cross-braced horizontally with $\frac{5}{8}$-in. steel-wire rope under the decking, and is quite stiff in a current of three knots. Cut baulks are used for the connections at A and B. All anchor cables are of 3-in. manilla cordage, except DP, which is of $4\frac{1}{2}$-in. cordage. The small weight on the steel haulage cable sinks that cable when the cut is open, and a similar weight can be attached to the cable EG.

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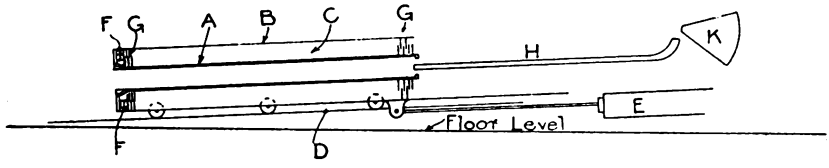
# "SPUN" IRON PIPES.

(STANTON DE LAVAUD.)

*By* E.M.S.

THESE pipes are now being used by the War Department (*vide* D.F.W. Contract Circular No. 843) and it is thought that the following notes on the process by which they are made may be of interest.

A very diagrammatic sketch is given, which it is hoped will be sufficient to give a clear idea of the essential features and arrangement of the plant and the method of using it.




A - Turned and bored cast chromium steel mould revolving in
B - Hollow carriage forming a water jacket C around A.
D - Inclined rails along which carriage B is moved backwards and forwards by hydraulic ram E.
F - Pelton wheel bolted to revolving mould.
G - Piston rings making water joint between mould and carriage.
H - Inclined grooved shoot cantileveted out along axis of mould.
K - Sector shaped ladle of capacity exactly equal to quantity of metal in pipe to be cast.

A chromium steel mould of the exact size and shape of the outside of the pipe required is so mounted in a water-jacketed carriage that it can be revolved at a high speed, while being traversed with the carriage at a definite speed parallel to the axis of rotation of the mould.

The traversing of the carriage is effected by means of a hollow hydraulic ram, working parallel to the axis of rotation and to the inclined rails on which the carriage runs.

The rotation of the mould is effected by means of a Pelton wheel mounted on it near the socket end, pressure water being brought to it through the hollow ram previously mentioned.

The carriage has a longitudinal axial travel of somewhat more than the length of the pipes to be cast, viz., 12 ft.

When the carriage is at the lower end of the inclined track, the spigot end of the mould, which faces up the track, just clears the

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outlet of an inclined, grooved shoot, so mounted and cantilevered out from the frame of the machine at the upper end of the track as to project downwards along the axis of rotation of the mould. This shoot is a trifle over 12 ft. long and the open end discharges to the side, *i.e.*, radially to the mould.

It will be clear that when the carriage is pulled up the track the outlet of the shoot is in a position to discharge its contents into the socket end of the mould.

Molten iron is brought by a Telfer transporter from the cupola and poured into a special sector-shaped ladle, which holds the exact quantity of metal required for one pipe, and is mounted on a horizontal axis about which it can be tipped at a constant angular speed. As the sector-shaped ladle is tipped, the surface of the iron has always the same shape and therefore uniform speed of tipping gives a uniform rate of flow of iron into the mould by way of the inclined shoot.

The inclination of the track, axis of rotation, and shoot are determined so as to give a suitable flow of hot metal through the grooved shoot.

The method of operation is as follows :—

The hollow mould has first to be completed by the insertion of a baked-sand annular socket core, mounted on a cast-iron supporting ring, which fits into the lower or socket end of the mould.

This core is required, as will be evident from the sketch, to form the socket of the pipe. There is no core for the main barrel of the pipe.

Water is then turned on to the Pelton Wheel, speed of revolution being about 500 revs. per minute. The carriage is meanwhile drawn up to the top end of the track.

The sector-shaped ladle is then tipped by hydraulic power at a predetermined speed, and the movement of the carriage down the track starts automatically at the moment when metal is first poured into the rotating mould.

The tipping of the ladle and the traversing downwards of the carriage are carefully synchronized, the thickness of the metal in the pipe barrel being obviously inversely proportional to the rate of movement of the carriage.

Every movement is, however, effected by water pressure and, after valves are once adjusted to suit a particular diameter of pipe, the process is quite automatic.

After the ladle has discharged its contents there is still sufficient iron in the shoot to make about two feet of the pipe barrel. It is found that the rate of flow of the metal at this stage slows down to a certain extent. This is compensated for by means of a trip valve, which slows down the speed of the carriage for the last portion of its travel.

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In order, however, to make quite certain that the thickness of metal is not deficient in the spigot end of the pipe, the carriage speed is reduced somewhat more than is necessary so as to compensate for the decreased flow of metal.

The lower or socket end of the pipe is now gripped by a pair of expanding tongs, the carriage is drawn upwards, and the newly cast pipe is drawn out on to rails, along which it is rolled to the annealing furnace. Each pipe is kept 40 minutes in the annealing furnace and slowly rolls through it at a uniform speed.

The time taken to pour a 12-in. pipe 12 ft. long is only 16 *seconds*, and the pipe reaches the annealing furnace in two or three minutes from the commencement of casting.

Temperature of pipe leaving mould, 800° F.

Temperature of hottest part of annealing furnace, about 1,800° F.

Temperature of exit from annealing furnace, 400° F.

After passing out of the annealing chamber, the sand core of the socket is removed and a wrought-iron band is shrunk on the spigot end to act as a bead. The pipes are then dipped in Dr. Angus Smith's solution and, when cooled, are tested hydraulically up to 600 lbs. per square inch.

The thickness of the pipe for similar pressure is about 25 per cent. less than would be the case in ordinary vertically cast pipes. The metal produced by this process is extraordinarily dense and the centrifugal action ensures remarkable uniformity of thickness. No air holes or imperfections of any kind are found, and the tensile strength varies between 18–20 tons per square inch. The resistance of the pipe to corrosion, owing to its dense character and the absence of any defects, is said to be considerably greater than that of an ordinary cast-iron pipe.

The form and general dimensions of the "spun" pipes follow the British Standard Specification, the external and internal diameters of the pipe and of the socket end respectively being of equivalent dimensions. They will therefore socket up with ordinary sand-cast pipes and specials without difficulty.

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# *OSBORNE.*

## THE HAVEN FOR CONVALESCENT OFFICERS.

THE object of this description, written during convalescence at Osborne, is to draw the attention of British officers of the Forces, and of the Civil Service, to one of their most splendid inheritances, the inheritance of Osborne, which King Edward relinquished, 22 years ago, for the well-being of those who were sick and sorry, and which has produced such a wealth of blessings, and such a measure of gratitude as even the thoughtful donor himself could never have foreseen.

The transformation of this royal residence into a convalescent-home for officers was based on a wise and simple plan. Wisdom is continued in the welcoming of every degree of convalescence (whether from wounds operation, serious illness, or even from mere over-work or general debility), and simplicity is exemplified in the procedure of admission, and in the modest scale of charges, as shown below.

Before studying the details of admission, etc., officers who contemplate restoring their health by "Leave-Home," may wish to know what Osborne and its surroundings and resources are like.

The chief glory is the great domain of garden and park, with its beautiful woods and dells, its wide acres of turf and gracious undulation, its noble cedars, ilex, evergreens and groves, and its ever-changing and magnificent views over the Solent and away to the Hampshire and Sussex downs. All these are a perpetual joy to the eye, and a solace to the spirit of a worn man.

With the exception of some of the "Royal Apartments," the whole of this spacious palace is at the disposal of the officers in residence. Consequently, even inclement weather fails to cause *ennui*, for one can study the pictures and statuary, the furniture and decorations, peculiar to what is called "Victorian Art," and, even if these splendours pall, recourse may be had to the excellent library and billiard-room, or to the wireless-concerts and the cinema in an adjacent room.

For those who begin to grow robust, there are, in the grounds, several tennis-courts, and an excellent 9-hole golf-course (provided with a professional), and even a rifle-range. Furthermore, all officers convalescing at Osborne are honorary members of the

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Royal London Yacht Club, Cowes, the Royal Victoria Yacht Club, Ryde, the Island Sailing Club, Cowes, and the Seaview Yacht Club, Seaview.

The whole of the Isle of Wight, with its wonderful natural beauties and its archæological and geological interests, is made " available " by means of the house Daimler, which can be hired at a moderate rate.

Life indoors is also agreeable, from the large, well-warmed and electrically-lighted bedrooms to the admirable bathrooms, from the most distant corridor to the nearest fireplace. The excellent, well-cooked meals are served in the fine dining-room, near which are the library and the billiard-room. The gorgeous smoking-room was formerly the Privy Council Chamber, and possesses a first-class floor, which is greatly appreciated during the Saturday-night dances.

The Resident Staff is presided over by the House Governor, Sir Warren Crooke-Lawless, K.C.V.O., C.B., C.B.E., C.I.E. (who made many friends in India when he was Surgeon to Lord Minto). He is ably assisted by a Matron (Miss Ormsby-Smith) and several skilled Sisters, and they by adequate valets, waitresses and house-servants, who, one and all, seem to have been selected for their " obligingness " (a virtue that pervades the whole of the House, and is extremely pleasant to meet).

Hence, the comfort of every officer is studied, just as carefully as his health—probably the former is a potent aid to the latter.

It should be borne in mind that the rigidity of " Hospital Regulations " is neither necessary nor enforced at Osborne, where a considerable amount of freedom is allowed (subject to the discretion of the House Governor), and where the hours for meals and for getting-up and going to bed are those of normal life in a country house, which Osborne greatly resembles.

Osborne is open for the reception of British officers of the following Services :—

(*a*) Navy.
(*b*) Marines.
(*c*) Army.
(*d*) Air Force.
(*e*) Civil Servants serving under the Foreign, Colonial, and India Offices, who are required to serve in tropical, sub-tropical or unhealthy climates, outside their country of origin.
(*f*) Officers of the Retired and Demobilized Lists of the above fighting forces (provided that retirement has occurred during the five years preceding the application for admission, but precedence is, of course, given to serving officers).

The total daily charges (which include medical attendance and

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convalescent nursing, medicine, fuel and light, and baths) are as follows :—

(i) For officers on the Active Lists of the Forces ... 6s. od.
(ii) For Half-Pay, or Retired Officers of the Forces ... 4s. 6d.
(iii) For Officers of the Civil Service detailed above ... (Under consideration.)

The following is the simple and direct procedure for an officer's admission to Osborne :—

The candidate, if an officer of the Forces, applies by letter to the Director-General of the Medical Service of the Force concerned (at the Admiralty, War Office, Air Ministry, India Office), and if a Civil Servant, to his Secretary of State. After a few days permission is given (if the candidate is suitable), and all that remains to be done is for the applicant to arrange with the House Governor as to the date and hour of arrival at Osborne.

In other words, everything is done to facilitate a convalescent's search for a peaceful, comfortable and interesting home, where his health can quickly be made good, and where he himself gains the hope of " making good " amongst his fellow-workers.

It is very depressing to see the numbers of officers " Home on Leave " who have no home, and to know that ill-health is the first cause of that leave, and the source of much financial worry, which is aggravated by the extortionate charges of sanatoriums, hotels, and " rooms " (whether in towns or in " health-resorts ").

Osborne saves an officer all such worry, and all the weariness which mere " Leave " cannot remove.

A proof of the excellence of (what may be called) the " Osborne Idea " is, that every officer who has once sojourned there invariably returns, if the later years have again deprived him of his health. So, in thinking of Osborne, one recalls the refrain of the old song, " *On y revient toujours.*"

" EXPERTO CREDE."

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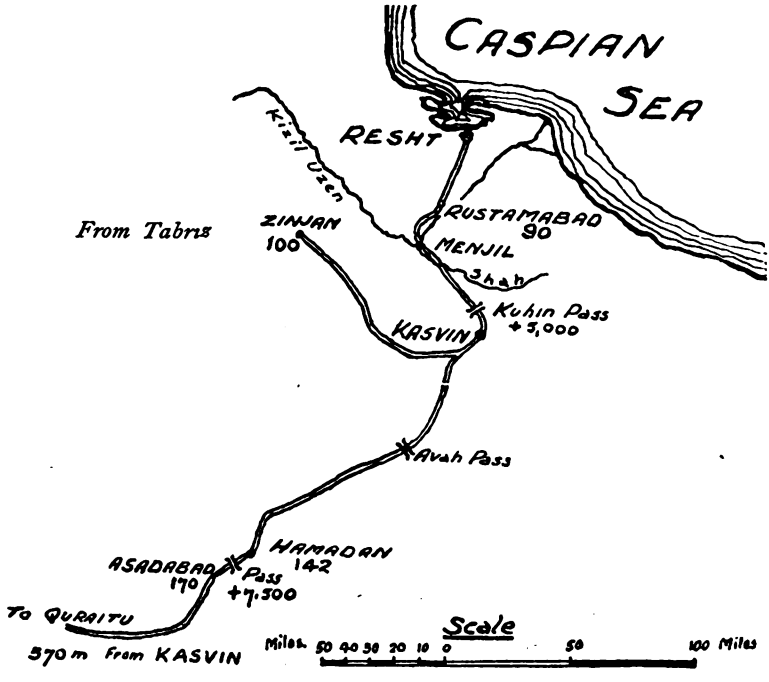
## *ENGINEER WORK WITH NORPERFORCE IN* 1919–20.

*By* MAJOR C. F. STOEHR, R.E.

PROBABLY many officers have read Major-General Dunsterville's *The Adventures of Dunsterforce* or M. H. Donohue's *With the Persian Expedition*, and thus know something of the curious adventures of our forces in that corner of Persia. But these books end their narrative before the Armistice, and few people know what happened subsequently in that region. The only book on the subject, the Hon. J. M. Balfour's *Recent Happenings in Persia*, had, unfortunately, to be withdrawn from circulation owing to its containing a legal —and perhaps actual—libel on a former Persian prime minister. It is still obtainable, however, and gives a good insight into many of the diplomatic events upon which the action of our forces depended. In this article an attempt will be made to give a general account of the engineering work done, with an outline military narrative as a background to this account and a supplement to the book.




After the Armistice the Batoum–Baku line was occupied by British troops, the force there forming part of the Army of the

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Black Sea. At about the same time General Dunsterville relinquished his command of Dunsterforce, which was re-named the North Persian, or, telegraphically, Norperforce. In April, 1919, the writer, with 19th Field Co. Sappers and Miners, joined the force and became its C.R.E. At this time Norperforce occupied Enzeli (on the Caspian), Resht, Kasvin, Hamadan, and Zinjan, but the last was evacuated immediately, and Resht during May; it consisted of a large mixed brigade, with headquarters at Kasvin. The country and neighbouring countries were quite quiet, except that round about Resht fighting between part of the Russian-officered Persian Cossack Brigade and local rebels under Kuchik Khan, in which we were neutral unless molested, was just fizzling out. The nearly-completed motor road from railhead at Quraitu on the Iraq-Persian frontier to Hamadan was held by "Percoms," a separate force with headquarters at Kermanshah.

The immediate problems confronting the C.R.E. were:—

(1) Barrack and road maintenance in the three occupied towns, with a personnel that was constantly melting owing to demobilization; (2) upkeep of the 290 miles of road between Hamadan and Enzeli; (3) the institution of some form of control over expenditure.

With regard to the first, the minimum requirements were six field engineers, and two of the existing six had to be released at once. Their places were filled by transferring one of the three (after August, two) officers from the Sapper company, and by making an R.E. Lance-Corporal, who was Acting-Serjeant, an Acting-C.S.M. and Field Engineer, Hamadan, where he was quite satisfactory during the four months for which he was needed there. The F.E. at Enzeli was a middle-aged civilian who had spent many years with a Baku firm and spoke Russian like a native. He was exceedingly good at getting work done quickly, though rather a trial over classifying and reporting expenditure. The other field engineers consisted of a young Territorial officer, whose pre-war engineering experience was confined to a year or two as an apprentice, and who had a curious habit of sleeping on his back with an electric light just above him, while in winter he kept a cat in bed, a large dog on the bed, and the door and window of his 11-ft. square room padlocked; a young Persian of about equal experience, who had been educated in England, fought in France with a British battalion and risen to be serjeant, and had been sent out to Persia when we became involved there; and a temporary R.E. officer who had done engineering work in Mexico, and had lurid tales of the revolutions there. Altogether it was a mixed team.

Subordinates were always a difficulty; there were no British personnel left, and only a few Assyrians of doubtful quality. Two or three excellent men were obtained from the 1/4th Hants (Territorial) Battalion, and by the time that this battalion was replaced by a regular one, which could not produce men with technical

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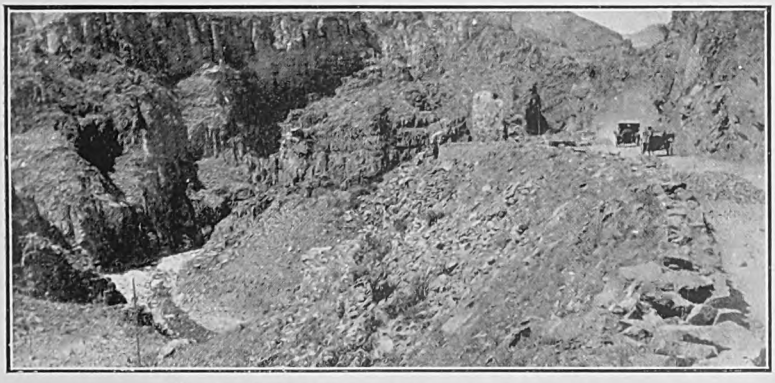
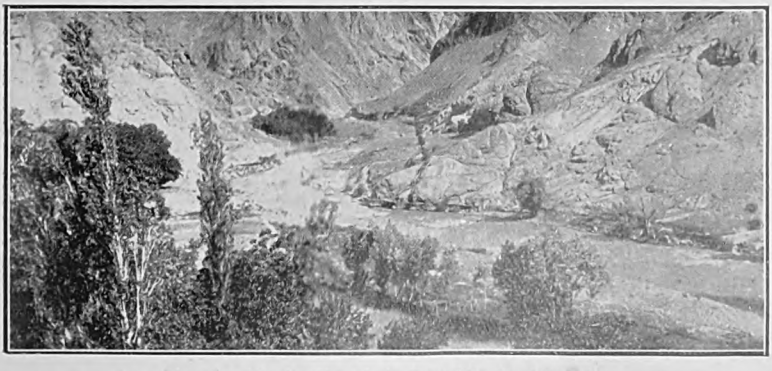
# ENGINEER WORK WITH NORPERFORCE IN 1919-20.

Pass near Tabriz, on Tabriz-Kasvin Road.

Tabriz Road, near Haji Agha.



Kasvin-Resht Road, below Yuzbashichai.



Kasvin-Resht Road, below Yuzbashichai.

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knowledge, the local subordinates had improved in numbers and quality and two British N.C.O.'s had come to the Sapper Company. During the first summer, also, much of the minor repair work, which was the most troublesome and difficult to supervise, was done by the Sapper Company.

At Kasvin, where most of the work was, and at Hamadan, all new work was done by contract. After plans had been shown to contractors, a Dutch auction was held, the man who made the lowest bid getting the contract. Generally speaking, fighting troops were in newly-built barracks and departments billeted in *serais*. All barracks were of sun-dried brick, with mud roofs on *ballis* at a 1/6 slope, and burnt-brick floors. Doors and windows were made up in our workshops and supplied to contractors. This type of building was quite satisfactory provided that it was made sufficiently early in the autumn to let the roof dry thoroughly, otherwise it was apt to leak badly during its first winter. The cost, which had been about 6 krans* per square foot in 1918, was gradually forced down to $3\frac{1}{4}$ krans, which was under $\frac{1}{4}$ of the cost of very similar, though rather better constructed, buildings at Baghdad. Eventually, after contractors had been educated up to it, contracts were made on a plinth area rate basis, a more satisfactory arrangement, because, on a lump-sum contract, it was difficult to change the plan, even in minor details, once the contract was signed, and people nearly always did change their minds about what they wanted. We were much better off for contractors than were Percoms, in whose area contract, and even piece-work, was hardly known when we first went there, while the north-west corner of Persia had been educated by the Russians. At Enzeli, where the soil was mostly sand and the cold was never intense, the troops were in huts with boarded walls and floors, and boarded or sheet-iron roofs.

Except for a few articles, mostly iron, all stores required were obtainable at Kasvin or Enzeli, or in a few cases from Teheran. The Field Park, Baghdad, was supposed to bill us for all stores supplied from there, but never did; we had some reason to think that the bills might be going to Percoms, but naturally did not enquire.

Furniture supply and issue was a big item. In 1920 issue was gladly transferred to the Ordnance Dept., and only the supply in bulk to the Ordnance, which caused comparatively little trouble, remained under the C.R.E.

A noticeable point was the way in which those Assyrians who, after their expulsion from Urumiah in 1918, had stayed with Norper-

* 10 krans = 1 toman = 4/- at normal rate of exchange, but actually varied from 6/- to 10/- till the autumn of 1920, when it went down, reaching 4/- in the spring.

One rupee = from 2 to 3·2 krans (normally 3·6 krans).

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force instead of going on to Mesopotamia, set to work to retrieve their fortunes. Nearly all the Works subordinates came from them, and, except for the Kasvin wood-contractor, an imperturbable little Persian, who took with a smile his innumerable fines for late delivery and whose monopoly we tried in vain to break, nearly all the contractors, and certainly all the best, were Assyrians. All those who were taken on as subordinates spoke English, generally with a strong American accent.

Various forms of heating were tried. For the winter 1919–20 stoves burning crude oil were made up and supplied, and, though not universally popular, were very efficient, provided that flues were occasionally cleaned and that the rate of fuel supply was watched. Water drips into the oil as it runs along an open channel into the stove, and turning to steam, helps to break up the oil. The Mesopotamian Force cooker, which works very efficiently on the same principle, was also introduced. For the winter 1920–21, when oil was not available, these stoves had to be turned into the Canadian pattern wood stove. An experiment very successfully tried in the R.E. Mess was an ordinary open hearth, with a 9-in. iron flue just clear of the wall, instead of a brick chimney. In this way nearly all the heat was given out in the room, the top of the flue being barely warm. In the winter of 1918–19 coal slack had been obtained from a mine near the Teheran road and briquetted in an improvised machine with the aid of a small proportion of clay. The Supply Dept. dropped the experiment, but a machine remained in the Field Park, and briquettes were always used in the R.E. Mess. The experiment would be well worth trying again in similar circumstances.

The road from Enzeli to Hamadan had been built by a Russian company, which recouped itself from tolls levied every 40 miles or so. Across the Elburz it ran for 70 miles through some very difficult country. It was well made and drained, but was not soled, and was only lightly metalled. An agreement had been made under which our troops were exempt from tolls but paid a monthly subsidy. Owing, however, to dissatisfaction at the way in which the road was being maintained we had ceased to pay the subsidy in October, 1918, had taken over the upkeep of the road in November, and during the winter had spent about £60,000 on it. For the financial year 1919–20 expenditure on it was to be limited to 120,000 tomans, which was a reasonable amount for normal upkeep.

We had no personnel, except one British officer and one Pole, formerly an engineer officer in the Russian Army, available for the work, but, luckily, the departing field engineer in charge, who had spent so much time in Russia that he spoke Russian better than English, had kept up friendly relations with the Company. An arrangement was therefore come to by which we took over and paid

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all their supervising and subordinate personnel that we needed. The local manager of the company himself was made a field engineer, and nominally given charge of a 100-mile sector, though actually he provided another official to do the work and pocketed the difference. In return for this trifling amount we secured his experience and advice, which were particularly useful during the first few months, and the use of the company's plans and records, and guarded against obstruction by any of the company's officials.

The custom was to collect metal by contract during the summer and spread it by daily labour during the autumn, shortly before the snow was expected. In the plain sections it was generally rolled, and on the hill sections allowed to consolidate itself under the snow and traffic. As we had only one steam and one bullock roller that could be made to work, we had to rely almost entirely on the latter method, and it certainly was surprising how well the new metal was consolidated when the snow disappeared. By May there was no time to lose in starting metal collection, and with the manager's assistance contracts were quickly placed. During the summer only permanent subordinates and a few coolies, including gang leaders, were retained, extra coolies being taken on locally when required. The main duties of the one British officer were to act as inspector, and report to the C.R.E., to see that work ordered was being carried out and that coolies paid for were actually present, and to pay all labour himself.

The system worked excellently and without friction. Whenever the road was blocked or damaged, as, in some parts, it fairly often was by local storms of extraordinary severity, the nearest gangs were quickly on the spot and at work. Officially, the company refused to recognize the new arrangement, and sent in a monthly bill for the tolls due since the subsidy ceased, of which they professed to have an accurate record; we retorted with a bill for the amount spent on maintenance, and as nobody on the Russian side had power to settle the question it remained in suspense up to the time of the evacuation; this monthly formality, however, in no way hindered work.

In April, 1919, there was an efficient local audit of all expenditure, and an estimate had to be sanctioned by the local Force Commander before any new work could be started. But there was no sort of control or classification of expenditure; field engineers reported at the beginning of each month what amount they expected to spend during the following month, and that was all the information about the very considerable expenditure going on—something like £5,000 a month—which the C.R.E. received.

Obviously, the first thing to do was to classify expenditure under different headings, Permanent Establishment, Major and Minor Works, Maintenance, etc., and make field engineers show what

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they were spending the money on; the next step was to tighten the control and have the expenditure on every job of work, whether new or maintenance, shown separately. Of course, this met with some opposition from F.E.'s, to whom it meant extra work, and probably seemed merely red tape; it must be remembered that from beginning to end there was no officer or subordinate in the force, except the C.R.E., who knew anything about Military Works routine. However, they soon realized that for outdoor work it was really not difficult, and in three or four months the system was working satisfactorily, except in the big workshops at Kasvin, which spent something like £2,000 a month on doors, windows, furniture, stoves, repairs to carts, etc. The classification and allotment of this expenditure really was a big and difficult job, which necessitated the pricing of every article made, and it was found necessary for one field engineer to devote his whole time to these workshops and other office work. At first there was a large discrepancy between the total monthly expenditure and the total output, calculated on the estimated cost of each article, but gradually this was diminished, and by December, when estimates for the next year were called for, every *kran* spent was allotted to some job and to its proper sub-head.

A constant difficulty was that, as there was no policy in London, or, at least, none that could be translated into definite statements of intention, no Works policy was possible. Recommendations or decisions about expenditure had to be made without the slightest idea how long the force was to stay in the country. For the same reason sanction to construct the barracks needed for the winter was always postponed till the last moment, or later, with the result that the roofs leaked badly during the winter after their construction. In 1919 there was no rain till December, and work was completed before it came. But in 1920 no orders were issued, despite urgent requests, till October 4th, and heavy rain fell in November, with snow and frost in December. Barracks and stables for an extra section of R.H.A. were actually ordered on November 9th; luckily, spare barracks were available, for the stable walls crumbled to dust under the frost and the roof was like a sieve.

A fact which added considerably to the interest of all the engineering work was that the force was so remote from Baghdad, and local conditions were so little known there and so different from those in Mesopotamia, that the Engineer-in-Chief left us entirely to our own devices.

The year 1919 passed peacefully. In August the Army of the Black Sea evacuated Trans-Caucasia, except Batoum; this made no difference at the time, as Denikin was in the full tide of success. In August, too, Percoms took over Hamadan and the road as far as Kasvin.

Early in January, 1920, it was thought that a brigade might be

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wanted at Tabriz, and an estimate was called for of the cost of making the existing road, from near Kasvin to Tabriz, fit for motor traffic. This estimate had to be based on a very rapid journey, the first 140 miles, which were easy, being done by a Ford van in two days, and the remaining 120, which included two passes with gradients of 1 in 5, being done, partly by cart but mostly by pack, in four days. Except for tea and cocoa local provisions were relied on, in the shape of Persian bread, eggs, honey, and *māst*, or milk curdled by some ferment which gives it a pleasant, somewhat acid, taste and is said to kill all disease germs. Fortunately, the flea does not appear to have invaded the ordinary Persian guest-house, for neither on this trip nor on others in the Elburz mountains was it met with. Fortunately, too, the winter hitherto had been exceptionally mild, and the maximum amount of snow met with was a few inches; a week after Kasvin was reached again there was a two-days' blizzard, and in a severe winter, such as the next one, communication even with Zinjan on the Tabriz road is broken for weeks at a time. Between Zinjan and Tabriz the country showed many signs of the famine of the preceding winter and of the depredations of the Shahsevans, a robber tribe who, in summer, haunt the district about 40 miles east of Tabriz, many villages being almost or quite deserted.

During the spring of 1920 Denikin's army collapsed, and on April 22nd the Red Army entered Baku. After the Armistice we had formed an armed merchant fleet on the Caspian, mostly Russian-manned, but with a stiffening of British officers and personnel, which forced the Red fleet to keep to the north end of the Caspian. When we evacuated Trans-Caucasia we made the fatal mistake, as it turned out, of handing this fleet over to Denikin. When his administration collapsed and the Bolsheviks seized the port of Petrovsk, the fleet went to Baku to offer its services to the Azerbaijan Republic, but could not accept the terms offered. The only course open to the fleet, therefore, was to come to Enzeli to be interned, which it did. The British Government, which, on the signing of the 1919 treaty with Persia had sent a financial, military and naval mission to Teheran, rushed out a naval party to take over the fleet, but Denikin's collapse was so unexpectedly rapid that on arrival at Baku the party found the town in Bolshevik hands and was made prisoner. At the same time, the melting of the ice at the north end of the Caspian released the Red fleet at Astrakhan, and their authorities lost no time in striking, for at daybreak on May 19th their fleet, escorting a number of transports, opened fire on our troops at Enzeli.

Here two low, sandy, jungle-covered spits of land, each some eight miles long and only a few hundred yards broad, enclose a very large shallow lagoon. The entrance, about 400 yards broad, between

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the ends of these spits is kept dredged, and forms the port, with the Persian town of Enzeli on the west and the Russian port and business buildings, forming the suburb of Kaziān, on the east side of the harbour. It was Kaziān that was held by our troops, who had been reinforced up to a strength of two battalions and some pack guns, and had mounted two or three guns of four and five-inch calibre from the fleet. The nearest reinforcement was at Kasvin, where there were half a cavalry regiment, two sections R.H.A., and two battalions.

The enemy fired a few shells, which did no damage, and began to land troops a couple of miles to the east of Kaziān. Militarily, the situation was by no means desperate, for the Red troops were of very little military value, and the fleet, being only merchantmen, could not have remained within reach of our guns. And though their 6-in. guns could have shelled Kaziān from long range, even accurate fire, which the shots actually fired gave no reason to expect, would only have hurt the buildings and not the troops in trenches. It was generally believed, however, and probably correctly, that the G.O.C.'s hands were tied by vague instructions, which, without giving him definite political guidance, prevented him from treating the situation from a purely military standpoint. In any case, a motor-boat with a flag of truce was quickly sent out, the Gurkha company which was driving back the enemy who had landed was recalled, and an agreement made by which our force retired to Resht that night, taking only such baggage as there was transport for on the spot. A fortnight later the force retired to Menjil, and the Bolsheviks, who professed only to have come to Enzeli in order to secure the fleet interned there, occupied Resht and set up a local Red government under Kuchik Khan, while, in spite of many promises, they have not yet (January, 1924) evacuated Enzeli.

This incident resulted in a serious blow to our prestige and in the loss of a very large quantity of petrol (which henceforth had to come from Baghdad), and of a considerable amount of other stores and private baggage. It was an object lesson in the value of sea-power, for the obstacles to an invasion by land were so great that it is improbable that the Bolsheviks would have attempted it if the fleet had remained under its British officers and continued to dominate the southern part of the Caspian.

At Menjil the Safid Rūd, which is fordable in places from about July onwards, enters a rocky gorge several miles long, and is crossed by a bow-string girder-bridge, with one central span of 54 ft. and three others of about 100 ft. each. Here one battalion and the pack battery formed a defensive position, with another battalion ten miles in rear. Two sapper jobs were, first, to prepare the 54-ft. span for demolition, which was easy, and second, to prepare

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a length of road in the gorge for demolition. This was much more difficult, for, though the road ran across the face of a rock cliff and at first sight looked easy to demolish, it was found necessary, on calculating the charge, to scarp the cliff below the road vertically to a depth of 30 ft. over a length of 50 yards in order to reduce the L.L.R. sufficiently. Even so, 600 lbs. of powder per mine were required, and five such mines at 30 ft. intervals were prepared, but eventually there was only sufficient explosive available to charge three of them. The result was good, 30 yards of road being blown away and a 45° rock slope left, but it took the enemy only three nights to make it passable for a lorry.

Towards the end of July the enemy approached and made a very half-hearted attack; he also brought up a howitzer which dropped shells into our camping area, and sent out some parties to harry our line of communication. These did no damage, though they succeeded in firing on the G.O.C. in his armoured car and shelled the other battalion's camp on one occasion. However, owing to fear for our L. of C. we suddenly withdrew from Menjil one night, after blowing down the 54-ft. bridge span. It turned out afterwards that the enemy, after a final bombastic summons to our force, had himself retired a day before we did.

Our troops now retired to Kasvin, leaving a tiny mixed force 20 miles out, where the road begins to dip down through the mountains, while a few miles behind this force the Persian Cossacks began to assemble. By now communication with Baghdad was cut by the Arab rising, and it was considered that any withdrawal from Kasvin was likely to bring in against us the Kurds, who live north of the Quraitu–Kermanshah road, so there was no alternative to fighting it out, if necessary, where we were. It had not yet been generally realized how contemptible as soldiers the enemy really were. Fortunately, the force had plenty of ammunition and obtained all essential supplies locally.

About August 20th our advanced force and the hostile force, which was camped some 14 miles beyond it, each decided to try to surprise the other by a night march on the same night. The enemy bumped into one of our camp pickets before dawn and ran away down the road; when a couple of miles from home, they came under a hot fire from our attacking party, which, at dawn, was a short distance above the road, having failed to reach the enemy's camp. The result of this shock was a hasty flight of the enemy, who covered the 100 miles to the Kaziān peninsula in three days, hotly pursued by the Cossacks, who had been on the point of taking the offensive, and more sedately followed by us as far as Menjil. At the peninsula, however, the Bolsheviks were reinforced and rallied, the Cossacks came under artillery fire from the sea and probably from the lagoon as well, and a charge by a party of enemy

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cavalry caused an utter panic, under the influence of which the Cossacks ran away to Menjil even more quickly than they had advanced. Here they were with difficulty rallied, while our force took up a better position 14 miles further forward.

The first job given to the sappers on arrival at Menjil was to build a trestle bridge about 100 yards long across the Safid Rūd, then 3½ ft. deep. The trestles were made from the roof of one of the barracks at Menjil, the road-bearers partly from the same source and partly from some 9-in. by 4-in. steel road-bearers from the big bridge, all the flooring of which had been burnt by the Bolsheviks as they retired, and the barrack floors furnished 6-ft. planks, which made a roadway just wide enough to take an armoured car.

As this bridge would be carried away by the first autumn floods, and, in fact, was carried away before it had been replaced, the depth of water increasing from 3½ ft. to 6 ft. in a single night, orders were given to replace the span destroyed in the big bridge, and to renew the roadway on the rest of the bridge. The materials available consisted of poplar poles up to about 28 ft. in length, poplar planks up to 9 ft., and plain and barbed iron-wire and nails as required; the only plant, besides that carried in the company equipment, was extra 3-in. rope and blocks, and perhaps a few jacks up to 3 tons. The new span was to carry light armoured cars and, if possible, loaded 3-ton Peerless lorries.

As the piers are about 30 ft. high and the bottom was obstructed by the fallen girder, anything in the nature of trestles was ruled out; wisely so, in the light of subsequent events. Calculations had already been worked out for plank girders, but in view of the tremendous gale which blows up the gorge daily except in winter, and the consequent difficulty of handling the girders, accentuated by the absence of flooring on the rest of the bridge, some other solution was desirable. Subsequent experience showed that the area exposed to the wind by the 60 ft. × 6 ft. plank girders would have made them completely unmanageable. At this juncture the head of the Road Company suggested the possibility of taking from one side of the bridge some of the 100 ft. long 9 in. × 4 in. R.S. joints which formed the road-bearers, putting them across the gap, and supporting them by diagonal struts from the piers. (See sketch, p. 262.) This solution was adopted. The existing bridge was about 17 ft. wide, and though two of the joists had already been used for the trestle bridge and lost when it was carried away, it was found possible to extract five more without reducing the width of the roadway below the 12 ft. over all which was wanted. They were taken across the gap by an overhead traveller, well tied to the existing road-bearers, and firmly held on the top of the piers by lime concrete. Each joist was then strutted as shown in the Figure, and the framework braced with barbed-wire Spanish windlasses.

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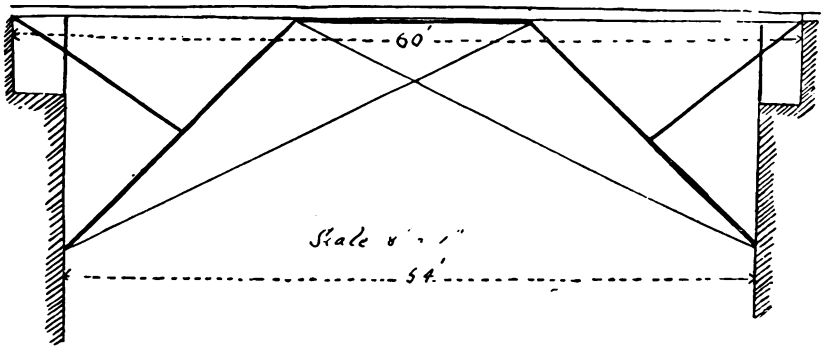
The struts themselves were then strutted and tied in their centres as shown, and cross-braced to each other, and the joists well tied together, with distance pieces.




A single 9 in. × 4 in. joist will not safely take the rear wheel of a loaded 3-ton lorry, and it took some time to find a way of distributing the weight over two joists without making the distance between the two outer joists so small that the chesses would project too far for safety. A solution was eventually found in using extra-heavy chessing, spacing the joists at about 2 ft. 3 in. centre to centre, and placing the wheel guides so that Nos. 1 and 2 joists took one wheel and 3 and 4 the other.

The new span was quite stiff vertically, but it was found difficult to get lateral stiffness, for the barbed-wire ties were rather elastic, but by carrying ties from the ends of the piers under the roadway to its far side and windlassing up as tightly as possible, and using two spars on one side where the piers projected sufficiently, enough lateral stiffness was eventually obtained.

The winter was of abnormal severity, and a fairly sudden thaw in the spring was accompanied by heavy rains, with the natural result of record floods. At Menjil the water rose to the lower edge of the bowstring girders, and trees, etc., brought down either broke or dislodged the struts and ties to such an extent that at the time when our force retired, after being relieved by the Cossacks, no single joist appears to have had both its struts in position, so that the joists were really spanning a 54-ft. gap. Moreover, the central pier of the bridge, at one end of the improvised bay, was showing signs of scouring, and had tilted so that its top was 2 ft. up stream of the line of the other piers, and it was also leaning slightly towards the other pier of the new bay; the R.S. joists were therefore distinctly distorted, and it was fortunate that the ends had been securely fixed, and that no heavier load than a field-gun had to cross.

Meanwhile, the Cossacks had recovered from their panic and gradually pushed the Bolsheviks back to between Resht and Kaziān.

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Towards the end of October, however, another sudden retreat in disorder took place, due, probably, to maladministration and consequent lack of supplies. This led to the dismissal of the Russian officers and the withdrawal of the Cossacks from the scene till the following spring.

On October 4th General Ironside assumed command of the force with a much freer hand than his predecessor had had, and at once began to issue the very urgently needed orders for the winter dispositions. These included new barracks for a cavalry regiment and British infantry battalion at Kasvin, the re-occupation of Zinjan by a battalion and pack battery, which necessitated numerous minor works and the presence of a field engineer, and finally the conversion of three tumbledown Persian villages into billets for the Menjil column, which included a British and an Indian battalion, section R.H.A., section armoured cars, and half a sapper and miner company. The work at Kasvin and Zinjan gave little trouble, but that for "Menjcol" was much more difficult to arrange for. The work itself was simple, consisting of propping up and repairing roofs, and in some cases making new ones, fitting of doors, oiled linen windows, and stoves, which were all made up at Kasvin, and odds and ends such as a concrete floor for the hospital bathroom. But the autumn rains were already beginning, all the field engineers were fully employed elsewhere, all skilled labour had to be sent down from Kasvin, the area covered was considerable, and, of course, everything was being clamoured for at once. The work had to be put in charge of the sapper and miner subaltern, with such scratch assistance as could be raised, till the completion of one set of Kasvin barracks released one F.E. and our best contractor. Eventually the troops were, if not made comfortable, at least housed in comparatively weather-proof buildings. An "Operations" heading in the expenditure account did away with any loss of time in preparing estimates for the work for Menjcol. One or two sharp lessons made the Bolshevik patrols keep well away from our area, and the troops remained undisturbed by the enemy, who displayed no further activity until after we had handed over to the Cossacks and withdrawn in April.

Hardly had the work for Menjcol been completed when heavy snowfalls began to block the road, but an account of our efforts to keep it open, and of the work connected with the withdrawal in April, has already appeared in the *R.E. Journal* for October, 1922.

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# *SUTLEJ RIVER HYDRO-ELECTRIC SCHEME.*

## An Appreciation.

*By* Maj.-Gen. A. C. de L. Joly de Lotbinière, C.B., C.S.I., C.I.E.

After certain preliminary surveys, river gaugings, etc., by P.W.D. Engineers, the Punjab Government in October, 1919, entrusted the preparations of this project in detail to Lieut.-Colonel B. C. Battye, D.S.O., R.E.

Battye's first step was to collect a staff of capable men, amongst whom were :—

Major R. N. Aylward, D.S.O., M.C., late R.E.
Major G. H. Hunt, M.C., late R.E.
Lieut. A. Guthrie, R.E.
Mr. R. K. Sibou.

The preparation of the project was then taken in hand in a thorough and systematic manner, each officer was allotted his section of the project, and the result has been a most exhaustive and comprehensive investigation of the project from every point of view.

The results of the above engineers' work have been embodied in five volumes which form most interesting and instructive reading, as every aspect of the generation, transmission and distribution of power over a large area of country has been fully discussed and investigated, and described in detail with illustrations.

As a rule people consider a hydro-electric power installation must be a most wonderful and complicated undertaking, as the electrical end of it consists of a mass of technical calculations and names which, to the uninitiated, convey little, but are really simple to an engineer.

The electrical end of the work is highly technical, but as long as the water-wheels turn round it is a matter of certainty as regards the electrical results.

What is a paramount and vital necessity to a hydro-electrical installation is to ensure the turbines turning day and night from year's end to year's end.

It is the solution of this problem which calls for engineering skill, resource, forethought and design. Having once solved this problem, and provided for every contingency, including extraordinary climatic conditions, the rest of the problem, *i.e.*, the generation, transmission

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and distribution of the power, generated by the turbines, is more or less a question of calculation and absolute certainty.

Electrical energy, in infinitesimal or gigantic volume, can be handled with equal certainty of results. The hydraulic question, however, is a far more unknown and difficult problem.

The fascination of a hydro-electric project lies in the harnessing of nature's energy, *i.e.*, in the extraction of the power derived from falling water, and no two schemes are similar in every detail. Every scheme has its own problems to be solved and contingencies to be provided against, and it is the engineering ability and foresight displayed in securing a continuous supply of water to the turbine which means the success or failure of the whole undertaking.

No amount of skill, money, or forethought devoted to electrical generators, transformers, transmission lines, or distribution, can result in anything but failure if the motive power breaks down.

In order to secure this motive power as far as engineering skill can secure it, the following points must be thoroughly investigated and provided for.

1. What is the minimum flow in the river, or from the river and impounding reservoir combined, that can safely be counted upon ?

The solution of this question can only be based on a series of river gaugings carried over a number of years, in which both the flood discharge and minimum flow are accurately measured.

2. The siting of the Head Works is an important point, and future enlargements of the installation have to be borne in mind.
3. The safe leading of the water, by open channels, by flume, by tunnel, or by Penstock to the forebay above the power station, or direct to the turbines, is always a question calling for great deliberation and skill.
4. Then comes the question of head to be obtained, the siting of the power house, disposal of tail-race water, and security of building from floods.
5. Financial questions must largely enter into all the above decisions, but it is bad policy to take the slightest risk of failure by saving money on any of these works.

The amount spent on any of the hydraulic components of the scheme must not be allowed to interfere in any way with the security of these works.

Turbines may be replaced, if not suitable, and all plant in the power station may eventually be discarded or replaced when worn out, but the bedrock of the whole scheme, *i.e.*, the continuous supply of water to the power house, must not be imperilled in order to save money in the first case.

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Having carefully gone over Lieut.-Colonel Battye's proposals and solutions of all the above points, I consider the scheme, as submitted by him, embodies a carefully, skilfully-planned and complete project, and one which, if carried out, will stand the test of time.

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The details of the scheme, as submitted by Lieut.-Colonel Battye, together with the plans and estimates, fill five volumes. It is therefore impossible for me to do more than give a broad outline of the proposal in a short article. Officers wishing to study the subject of hydro-electrical generation and transmission of power will find it will well repay them to go carefully through the details of this great project, a complete copy of which will be found in the R.E. Library.

The proposal, broadly, is to take advantage of the fall in the Sutlej River, which occurs in a great loop of about 50 miles in length which the river forms in issuing from the hills. The river, in issuing from the hills, is met by a spur which forces it to change its course from south to north-east and back again south-west. The loop so formed is about 50 miles in length and the distance across the neck of the loop is about 5 miles.

The difference of level between the surface of the river across the neck is 443 ft. Owing to the gentle slope of the ground on the south side of the range 79·5 ft. cannot be developed to advantage, but by excavating an artificial tail-race 40 ft. deep a total net head of 328 ft. will be available after deducting loss of head in tunnel and penstocks.

It is proposed to drive a 20-ft. diameter tunnel through the neck; this tunnel will have a length of 2·16 miles; from the lower end of the tunnel five 10-ft. diameter steel pipes 1·8 miles in length will convey the water under a pressure of 328 ft. head to the turbines in the power house.

The discharge (minimum) of the river from a series of gaugings extending over a number of years has been taken as 3334 cusecs, and in the first case it is proposed to install plant to utilize this discharge only.

This flow of 3334 cusecs under a head of 328 ft. will generate 80,000 kw.

As demands arise for further power it is proposed to build a dam to impound flood water, to supplement the available winter flow. This dam would have a height of 140 ft. and would impound sufficient water to ensure a discharge of 6,600 cusecs all the year round.

The main transmission lines will have a length of 195½ and 185 miles with a pressure of about 140,000 volts. Branch lines pressure, 44,000. Three-phase alternating current at 50 cycles will be employed, as this will do for both power and lighting.

Detailed descriptions of all hydraulic and electrical plant in the

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power house and transformer buildings, transmission lines, sub-stations, etc., are given in the estimate.

The question of financing the scheme and the probable returns to be anticipated are also carefully gone into, and from the figures given it is shown that eventually the scheme will pay well.

Personally I consider that the financial forecast of returns is conservative, and that the sale of power after the plant has been in operation for a couple of years will be considerably in excess of that anticipated.

Cheap power has a magnetic influence on industries and manufacturers, and draws them irresistibly within reach of the tentacles of a power station, when it is realized that the power can be depended upon, and that contracts for a long period of years can be made at rates for power which will not vary as does the price of coal. When once this truth is grasped the demand for power should quickly reach the capacity of the generating plant.

I was speaking to a Canadian manufacturer last week who has recently made a contract, extending over a long term of years, for the supply of 200,000 h.p. He is building his mills in the vicinity of the hydro-electric power station, in order to obtain power at a bedrock price. The plant to supply this power is not yet completed, but I venture to predict that, when it is ready to operate, the whole of its output will be sold.

India has not yet generally reached the stage of fully appreciating the blessings of cheap power, but when it does, then the many snow-fed rivers of the Himalayas will be used to their full power capacity.

I sincerely trust that this great undertaking in the North of India will be put in hand without delay.

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# *THE KHYBER RAILWAY.*

(Reprinted from *The Railway Gazette* of 17th September, 1923.)

THE CONSTRUCTION OF THE KHYBER RAILWAY, ONE OF THE MOST REMARKABLE LINES IN THE WORLD, IS PROGRESSING RAPIDLY. IT WILL CONNECT INDIA AND AFGHANISTAN.

The Government of India decided in 1920 to construct a railway over the Khyber Pass from Jamrud, the present terminus of the North Western Railway of India, to the Afghan Frontier as a single 5 ft. 6 in. gauge adhesion line. The total length is 26·84 miles, but only 26·13 miles will be laid up to Landi Khana, the remainder being formation up to, and just across, the Tora Tigga nulla in the direction of Dakka. The mileage is calculated to the centre of the four reversing stations, two on the ascent and two on the descent (including Landi Khana). The whole railway lies in independent territory in the Khyber Agency of the North-West Frontier Province, and it is contemplated to carry the formation up to the boundary with Afghanistan.

The reduced level at Jamrud is 1,496, at Landi Kotal (the summit) it is 3,495, and at Landi Khana it is 2,622.

There are altogether 2·55 miles of tunnels, but none exceeds 1,400 ft. in length. There are only two high viaducts, one 55 ft., the other 80 ft. in height. There are seven crossings of the Khyber nulla, but bridging is, otherwise, not heavy. There are 10 crossing stations on this railway, but it is proposed to open eight only, and to leave two as "flag" stations to be laid and worked in case of a large increase of traffic.

In the location of the line political considerations had naturally to be given considerable weight, and for convenience of description it may be divided into sections between controlling points and described as follows :—

(*a*) From Jamrud to the jaws of the Pass the earthwork is comparatively light near Jamrud, but gets heavier and heavier with a deep cutting at the jaws in limestone.

(*b*) From the jaws of the Pass the line swings right-handed and crosses the Bagiari nulla and the Khyber motor road by a bridge of five spans of 40 ft. with piers 55 ft. high. Thence, swinging left-handed again through two tunnels, it crosses the Kafirtangi nulla on a bank 60 ft. high and reaches the lower reversing station, Medanak, at mile 5.

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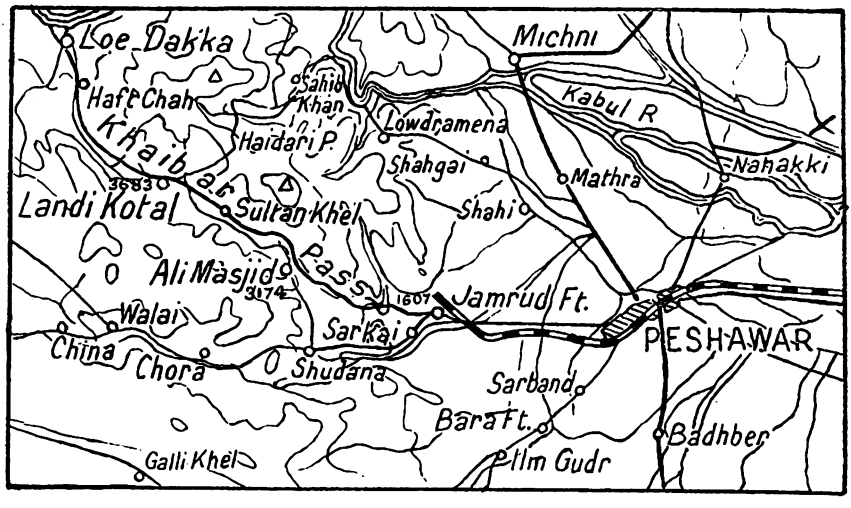
From there it follows the main Kafirtangi nulla until it passes through the spur by the long curved Kafirtangi tunnel (1,400 ft.) and, climbing up its south face, crosses the spur in cutting near its summit to reach the second reversing station, Changai, at mile 6¾. These two reversing stations, 1¾ mile apart by rail, are thus strikingly situated one above the other on the same hillside with a difference of level of 184 ft., though only some 350 ft. apart in plan at their nearest points. The staff for both will be accommodated in a defensible tower on the crest of the ridge, which commands a fine view of the eastern side of the pass and the vale of Peshawar beyond.




(*c*) From Changai reversing station towards the Shagai plateau the line first follows the Changai spur, crossing over the top of the Kafirtangi tunnel. It keeps on the south side of the spur, which is very steep and denuded of soil like most of the hillsides in the Khyber. Though the dip is favourable, the cleavage of the shale beds makes them none too stable and heavy work, including four tunnels and a 45-ft. retaining wall, is required. At the point of junction of the spur with the main mass the line curves to the south and passes in tunnel through Barley Ridge, which may be regarded as the edge of the plateau. It then follows a winding ravine, a tributary of the main Khyber Nala, to a comparatively good station site on the plateau, close to the two roads at this point.

(*d*) From the Shagai Plateau through the Ali Musjid gorge, the approach to the gorge is barred by two long spurs with two deeply indented ravines. It is necessary to tunnel through both spurs and to have heavy banks in the ravines. The line has been taken through the gorge at a high level, since both roads have been taken at a low level and the interference with them at a lower level would have been intolerable. The gorge consists of stratified limestone in thick layers. Although aggregating 3,360 ft., the tunnels can be pierced from many faces and adits and will probably require very little full lining. The

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grade through the gorge is level so as to bring the line down to valley level at Katakushta, and also on account of the very strong winds which blow in certain seasons.

(*e*) From Katakushta to Landi Kotal. In this section the earthwork is heavy in a few places only, but the Khyber stream wanders from side to side and altogether seven crossings (major bridges) are necessary. The station side at Landi Kotal lies to the south of the curved Ghatzai Ridge, somewhat away from the camp, but it is necessary to tackle the descent to Landi Khana.

(*f*) From Landi Kotal to Landi Khana. Here the grade has become 4 per cent. At first the drop in the main water course is comparatively easy, though waterfalls make it impossible to keep close to the valley for long. The side ravines are deeply indented, making it necessary to tunnel through the spurs and introduce one viaduct. But at Michni Kandao the country falls right away. The spurs become more indented than ever on the north. On the south the slopes are very steep and are unstable for geological reasons. It was necessary to curve northwards, to tunnel through the long spurs and attain the Tora Tigga nulla, which flows into the main nulla below Landi Khana. A reversing station was sited as high up this nulla as possible and the 4 per cent. grade was then barely sufficient to keep down to the general rate of fall. The side ravines are deeply cut and the earthwork is very heavy. Between Landi Kotal and Landi Khana there are 15 tunnels aggregating 1¼ miles.

The terminus at Landi Khana is on ground which cannot be described as ideal by any means, but it is situated well within the frontier.

## Grades.

The ruling grade from Jamrud to Shagai is 3 per cent. (1 in 33·33), from Shagai to Landi Kotal (the summit) it is 2·5 per cent. (1 in 40), except for a length of 4,000 ft. on 3 per cent. This length can usually be operated by taking a run at the grade, but the high winds will probably restrict loads to the same as on the 3 per cent. grades. From Landi Kotal to Landi Khana the descent is on a 4 per cent. grade. All grades are compensated for curvature at the rate of 0·30 per cent. for a 7-degree curve or 0·043 per degree of curvature. The same compensation is given for the very few curves of easier radius. As a comparison it may be mentioned that the steepest grades on the motor road are about 1 in 9 and 1 in 13 respectively.

Vertical curves 200 ft. long have been introduced at changes of grade, approximating to a curve of 3,274 ft. radius on a 4 per cent. grade.

## Curvature.

The sharpest curve is of 7 degrees (818·51 ft. radius). This is practically the same as the curve to a turnout with a 1 in 8½ crossing

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for the 5 ft. 6 in. gauge; 51·8 per cent. of the line is on a curve. Transition curves will be 105 ft. long, equal to 15 ft. per degree of curvature. This gives a rate of increase of super-elevation of 1 in. in 30 ft., assuming super-elevation for 25 miles per hour.

## GEOLOGY.

The rock generally consists of a hard deep-blue or black shale, sometimes splintered with soft pockets in it, and bands of limestone often of considerable thickness. The slopes are much denuded of soil, which has accumulated to a considerable thickness in the bed of the Khyber valley and in the fans of debris extending outside the Khyber range on both sides. This soil contains a high proportion of boulders small or large, and the lime abounding in the range causes a certain amount of cementation. None of the soil is comparable to the silt of the Peshawar vale, for instance, much less to that of the great plains of India. The larger ravine beds are deeply scoured and filled with debris to a considerable depth, so that rock founds to bridges are obtainable only on the slopes.

The slopes are extremely steep, even precipitous in places, such as in the Ali Musjid gorge, and there are several small waterfalls. Owing to the scanty and stunted vegetation the rain, which rarely falls on the area, has a high proportion of discharge. The larger waterways are dry for long periods, but come down as a wall of water after rain. Some of the water may be absorbed in those beds which have a long length of loose debris. There is a well defined strike in the rocks running east and west and a steep dip of 40 to 55 degrees to the north. Consequently the line has been located as far as possible on the southern slopes and where not so located has been kept in bank generally.

The water-bearing area is limited, although small springs can, in a good year, be found in several places. The last two years have been deficient in rainfall. There are, however, strong springs in the Ali Musjid gorge, and above Landi Khana. These are possibly snow-fed, but their persistence is mysterious, for the steep dip would bring their horizon to the surface in quite a short distance. The country is said to be liable to earthquake, but in the last three years no more than moderate shocks have been experienced.

Although a careful look-out has been kept for them, no fossil or useful minerals have so far been found, except a black substance described by the Director of the Geological Survey of India as "very inferior coal," which would not repay working.

## CONSTRUCTIONAL DIFFICULTIES.

The line is unique in being situated entirely outside the administrative border of British India in the strip of the tribal territory which separates it from Afghanistan and over which only a limited

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degree of political control is possible. For this reason all the "contractors" employed are influential tribesmen who have had no experience of such heavy work. All skilled labour has therefore to be imported and is in nearly all cases directed by the railway engineers themselves, the only important exception being that a European contractor with tunnelling experience has been actively associated with the tribesmen "contractors" in the case of 11 out of the 32 tunnels on the line. The unskilled labour employed consists almost entirely of local tribesmen. All the staff and the labour employed on the line have to be accommodated in camps with defensible perimeters formed by wire entanglements, for protection against tribal raids; and this principle has also to be applied to the permanent station buildings.

Good limestone for building is found in a few places, and when burnt it provides a pure "fat" lime. Bricks are being burnt at Islamia, near Jamrud, and at Landi Kotal, but are only used for tunnel lining. Brick-bats are ground at the kilns to a fine dust, called *surkhi*, which, when mixed with the fat lime, acts as an artificial *puzzolana* and forms a fair hydraulic mortar. But it is found in many cases that cement concrete is cheaper than either brick or stone construction, now that a large supply of first-class cement is obtainable in India at a fairly reasonable price from the Bundi Cement Co. Ltd.

## The Permanent-Way.

The line is being laid with a heavy flat-footed rail of the British Standard section on deodar sleepers with bearing plates and dog-spikes. The standard points and crossings have 12-ft. switches and a crossing angle of 1 in 8½ to suit the 7-degree curves. Each station will be protected by a slip siding at its lower end to prevent loose vehicles running away on to the main line, and by a catch siding at its upper end by which a train descending at a dangerous speed can be diverted on to a very steeply rising line with sanded rails, and brought to rest without damage.

It is proposed to work the line with the heavy 2-8-0 goods engine already in use on the North Western Railway. Each train will be fully vacuum-braked and will have two engines, one at each end; the maximum load of goods trains will consist of 22 four-wheeled vehicles (about 385 tons gross). Although this train would only require a length of about 700 ft., the sidings are actually 1,100 ft. long to allow for longer trains of lighter passenger vehicles or for the introduction of more powerful engines, which the new running dimensions make possible. This is the first 5 ft. 6 in. gauge line to be built to these dimensions, which were recommended for important lines by the Government of India in 1921 and allow for a maximum running width of 12 ft. and height of 16 ft. instead of

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10 ft. and 13 ft. 6 in., respectively, as at present. All bridges are being built to the latest Indian standard loading, *i.e.*, an axle load of 24 tons.

### PARTICULARS OF PLANT USED.

The increasing cost of labour in India has rendered economical the use of construction plant and methods usually found only in more civilized countries. A large fleet of "Sentinel" steam wagons and Fiat lorries is being employed for the transport of materials both up the main road and on the service roads up various side nullas constructed specially for railway purposes. Their cost is only about two-thirds of that of country bullock carts. In the tunnels, drilling is being done by Ingersoll-Rand jack-hammers, the compressed air for which is supplied by portable petrol-driven air compressors by the same makers. These have been hauled up the mountain sides to work in many places where no heavier type of plant could have been taken. The larger tunnels and labour camps are lit by electric light supplied from generating sets of Petter & Parsons engines coupled to dynamos made by the Lancashire Dynamo and Motor Company. Ransome concrete mixers are in use on some of the large bridges and retaining walls, while for the construction of buildings the Australia concrete block-making machine, fed by a small Tonkin mixer, has proved most successful. In a country where timber does not exist and has to be imported at great cost, the use of the self-climbing steel shuttering, made by the Climbing Steel Shuttering Company, has proved of great value, not merely in the construction of ordinary walls but even in mass concrete work for retaining walls and culverts. Many of the latter are being made of the curved "elephant shelters," familiar as the roofs of dug-outs to all who served in France, with a ring of cheap concrete above them.

The estimated cost of the line is approximately Rs. 1,97,00,000, and it is hoped to be able to open for traffic next year. The survey and earlier stages of construction were under the direct charge of Lieut.-Colonel G. R. Hearn, D.S.O., R.E., Engineer-in-Chief, acting directly under the orders of the Railway Board. Since his appointment as Chief Engineer of the Eastern Bengal (State) Railway the administration has been placed under the North Western (State) Railway, of which system it will form an extension. Major E. P. Anderson, D.S.O., R.E., is in direct charge as Superintendent of Works, with Mr. V. Bayley, C.I.E., and Captain J. R. Roberts, M.C., R.E., in charge of the two construction divisions, and Mr. A. Maitland in charge of a third division comprising the stores, workshop, and charge of running and repairs to plant throughout the line.

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# *REINFORCED CONCRETE CHIMNEY SHAFT AT THE ELECTRICITY WORKS OF THE CITY COUNCIL, GIBRALTAR.*

*By* MAJOR H. E. COAD, A.M.INST.C.E., S.R.E.S.

THE original steel chimney of the Electricity Works, 90 ft. high, 3 ft. 9 in. diameter, of $\frac{3}{8}$-in. metal, erected 20 years ago, having corroded to an unsafe condition, it was decided by the Gibraltar City Council to replace it. After consideration of brick, steel and reinforced concrete shafts, the latter construction was decided upon. The Crown Agents for the Colonies were accordingly communicated with, and eventually the Yorkshire Hennebique Contracting Company, acting as contractors executing the design of Messrs. L. G. Mouchel & Partners, Ltd., obtained the contract.

The contractor stipulated that the foundation subsoil should be guaranteed to bear 3 tons per square foot, and the Council accordingly prepared the necessary concrete foundations to ensure this.

A flue temperature at the top of the new shaft of 800° Fahrenheit was calculated for, although 400° Fahrenheit at the base of the old shaft had been the maximum recorded.

A reinforced concrete buttressed foundation, deep enough to contain the two flues, which are of arched section 3 ft. 9 in. wide and 7 ft. 6 in. high, was first prepared, and on this the reinforced concrete blocks of the shaft proper were laid. These blocks, as shown in the drawing, are of five different sections of equal depth of 10 in., varying as the shaft rises, from $38\frac{1}{2}$ in. to $25\frac{1}{4}$ in. long and 8 in. to 4 in. thick. One end of each block is hook-shaped, to take the vertical reinforcing bar in each of the 10 vertical joints, and these joints are further strengthened by $\frac{3}{16}$-in. stirrups.

At each horizontal joint is a circular reinforcing bar which is laid in cement mortar in a V-shaped groove in the top surface of the blocks.

The blocks themselves carry reinforcement of two horizontal bars spaced above each other, and these turn around the hook, giving strength to the weakest part of the block. These reinforcing bars are connected vertically with a $\frac{3}{16}$-in. wire. The blocks were cast in moulds and are of concrete made to the following specification:—

"Unless the proportion of voids in the aggregate is greater than 50%, the concrete shall be mixed in the following proportions:—

6 cwts. of cement,
$13\frac{1}{2}$ cubic feet of sand,
27 cubic feet of aggregate.

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The proportion of voids in the aggregate shall be accurately determined by the contractor, from time to time, and if the proportion of voids exceeds 50%, the volume of sand and the weight of cement shall be proportionately increased, and the mortar shall never be poorer than the foregoing specified quantities."

The blocks took three to four days to set sufficiently to be moved from the moulds.

The height from ground line to summit of the new shaft is 101 ft. 10 in., the internal diameter at the base is 10 ft. 6 in., and at the top 7 ft. A 4½-in firebrick lining is carried to the top of the shaft, giving a minimum air space of 2½ in. between the lining and the concrete.

The time for erection was six months, and the whole work was carried out by a small gang, consisting of a foreman, a constructor, 2 bricklayers and from 4 to 6 labourers.

No external scaffolding was employed; an internal stage, supported on four of the firm's patented expanding putlogs, being gradually raised as the work proceeded. These putlogs consist each of two loose steel rods sliding inside and at each end of a steel pipe to which they are rigidly fixed by studs when in position. The outside ends of the rods are splayed, so as to fix easily in the horizontal joints of the chimney.

An electric power winch was used for lifting the blocks inside the shaft.

By these means, the constructional part of the work was of the simplest description and at the same time extremely efficient.

The cost of the shaft complete from foundation level, with outside steel ladder and lightning conductor, was £1,850.

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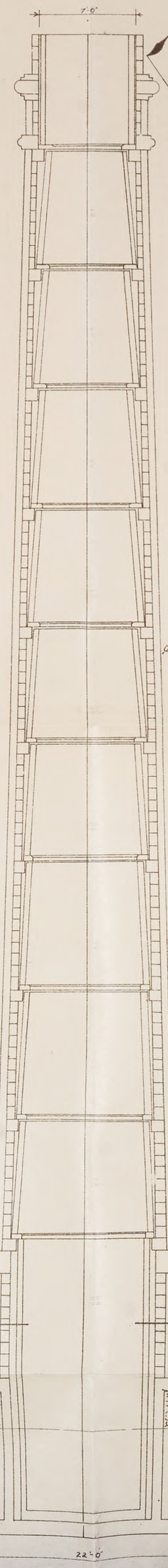
# CHIMNEY AT GIBRALTAR.

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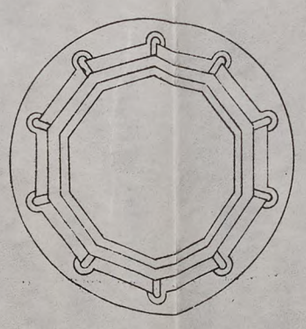

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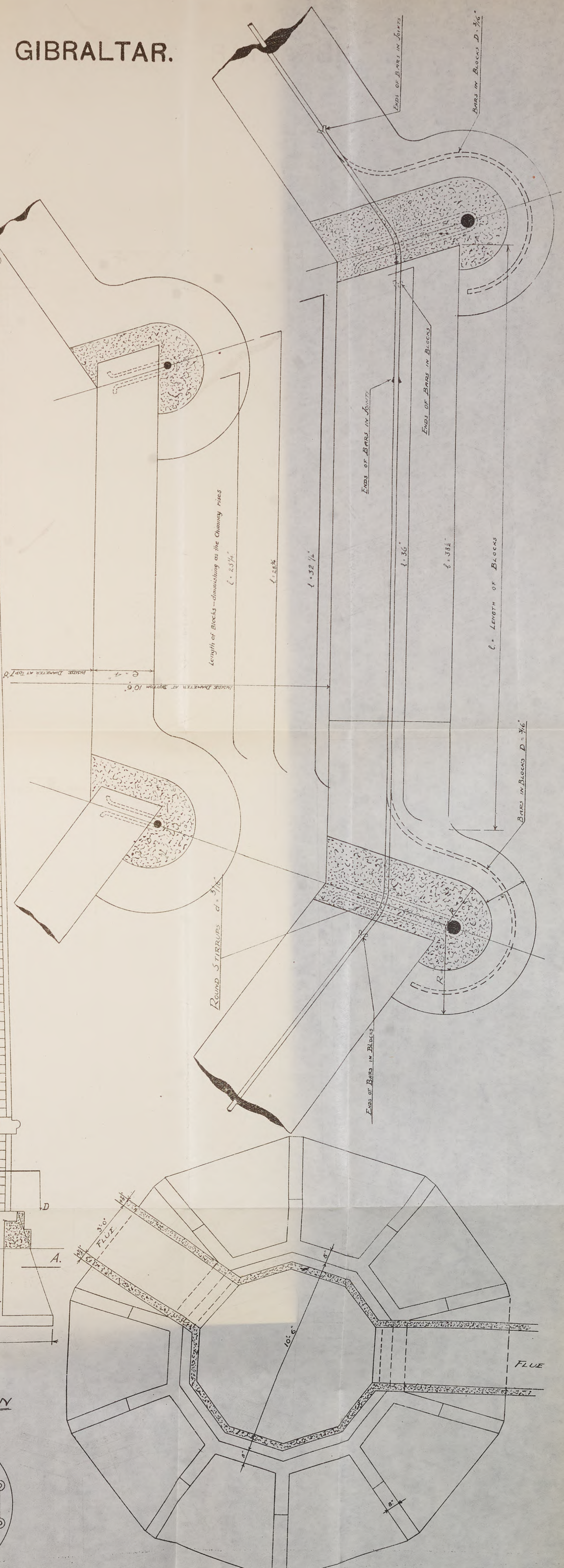


SECTION A.A.

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# *HISTORY OF THE 12th COMPANY ROYAL ENGINEERS.*

*By* LIEUT. M. R. CALDWELL, R.E.

## INTRODUCTION.

IT is a very difficult task to trace the work or continuity of any particular Company, during the early days of the Corps, as Royal Military Artificers and Royal Sappers and Miners, owing to three causes; first, to the fact that between 1778 and 1815 the Corps was being constantly increased and reorganized; second, because, subsequent to this, owing to reductions in the Army generally, many companies were disbanded; and third, because it was a very old-established custom for the Companies to be known by the names of their respective stations, so that when they are numbered for the first time, and again renumbered and moved, records become somewhat confused.

However, as far as the history of the 12th Company is concerned, there are four well-defined periods into which it falls. First, at the end of the eighteenth and beginning of the nineteenth centuries until 1817, the old Nova Scotia Company; second, from 1819 to 1834; third, when an extra "Service" Company was formed in 1846 and called the 12th, subsequently becoming a Fortress and afterwards a Depôt Company until 1885, and fourth, from 1885 onwards, since when the 12th has been a Field Company.

In spite of the fact, however, that these four periods represent four different units, each of which in turn bore the same number, and not four phases of the same unit, the three former periods will be sketched briefly from the point of view of general interest.

## PART I.

Under a Warrant dated September 5th, 1806, by which the Corps of Royal Military Artificers was increased and reorganized, numbers were for the first time allotted to Companies.

The one given the number "12" was the old Nova Scotia Company which had already been in existence some years and was stationed at Halifax. It had been first formed under a warrant bearing the date 21st July, 1784, when it was laid down that at each of ten stations, among which was Nova Scotia, there should be one Company. The original officers with the Company were Captain John Cambel and Lieutenant William Booth, whilst on January 1st, 1801, Captain William Fenwick is mentioned as commanding, with Serjeant John Catto as his Serjeant-Major.

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At the time when the number " 12 " was first given to the Company Captain William Bennett was the Commanding Officer.

The drill and discipline of the Companies stationed abroad at this time appear to have left much to be desired, owing perhaps to the small importance attached to soldierly appearance and achievements as compared with " the Works." Also a large number of the N.C.O.s and men were often much too old. However, about 1808, Lieutenant John Oldfield of the Royal Engineers, an officer who subsequently rose to distinction, and who had previously held the position of Adjutant at Portsmouth—the then model station for discipline—was removed to Halifax and appointed Adjutant there.

The materials upon which he had to work were mostly old in years, unused to very strict discipline and somewhat addicted to intemperance! In spite of this he managed, by means of regular drills, to mould them to an appearance which enabled them to march past creditably with the Line on Sunday Garrison parades! But, although not very tight and tidy soldiers, they were very valuable artificers and good workmen.

The practice of calling the Companies by numbers soon fell once more into disuse and although the Company still remained at Halifax, the number " 12 " had disappeared by the time the Corps was once more reorganized in May, 1812, in four Battalions of eight Companies each. The Company was then called the 5th Company of the 4th Battalion. Each Company consisted of 89 rank and file.

By a warrant of March 6th, 1813, the title of the Corps was changed from " Royal Military Artificers " to " Royal Sappers and Miners."

There seems to be but little record of the activities of the Nova Scotia Company, except that in 1809 one of their N.C.O.s was employed on a tour of inspection of the works on Cape Breton and Prince Edward Islands, while in August and September, 1814, a detachment of a Colour-Serjeant and 6 men under Captain Gustavus Nicolls was attached to Sir John Sherbrooke's expedition, and was present at the capture of Moose Island, Castine and Belfast (Maine). After this the Company was mainly employed on harbour defences and the works on Sherbrooke's Tower on Mangers Beach.

In February, 1817, the 4th Battalion was disbanded and with it of course the one-time 12th Company. It was replaced at Halifax by the 2nd Company, 3rd Battalion, from Woolwich, in 1818.

## PART II.

In 1819 a further reorganization of the Corps took place, the three Battalions being abolished and the Companies once more numbered consecutively.

The 12th Company was formed at Portsmouth on March 1st under the command of Captain and Brevet-Major T. Blanshard, R.E.,

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C. Upton being the Colour-Serjeant, there being in all 75 rank and file.

In March, 1822, the Company embarked on H.M.T. *Salisbury* at Plymouth and sailed for Bermuda. Here they remained until April 25th, 1829, when the Company, under the command of Captain R. Kelsall, embarked for Home on the *Flora*, disembarking early in May and proceeding to Woolwich.

After 21 months at this station the Company moved to Chatham in February, 1831, for two years, when they were once more ordered to Bermuda, embarking on the transport *Orestes* at Woolwich on 1st March, 1833, and arriving at Ireland Island, Bermuda, on the 31st.

While here, Lieut. A. C. Orlebar met with a fatal accident, being drowned by the upsetting of a boat while out sailing near St. Georges on 10th February, 1834.

The Corps was now down to a total of 12 Companies, three of which were Survey. The Companies were therefore re-arranged and renumbered, the old 12th Company becoming the 5th and the number " 12 " once more disappearing on February 28th, 1834.

## PART III.

On April 1st, 1846, a new Company of Royal Sappers and Miners —the 12th—was formed at the Depôt at Woolwich under the command of Captain Theodosius Webb, R.E., with Michael Bradford as the Colour-Serjeant, and an establishment of 100 N.C.O.s and men.

In August, 1846, the Company proceeded to Chatham for a short time, returning to Woolwich in March the next year.

On September 26th, 1848, the Company, under the command of Captain G. C. Baillie, embarked at the Royal Arsenal on the *City of Manchester* for Gibraltar, where they relieved the 11th Company. They remained here eight years, during which time one of the officers—Lieut. Gilley—died of phthisis on the 18th June, 1856.

On August 30th, 1856, a cadre of the Company under Colour-Serjeant P. Leitch, embarked for Home on the *Crest of the Wave*, disembarking at Portsmouth on September 14th and proceeding to Chatham. Here the Company was once more made up to strength, none of the old officers and but few of the men, however, being still on its rolls.

Colour-Serjeant Leitch, who had won considerable honour in the Crimean Campaign, notably before Sevastopol, and had been awarded the Legion of Honour and been recommended for the Victoria Cross, had been transferred from the 2nd Company soon after they arrived at Gibraltar in 1856.

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After the Crimean War the Army was considerably reorganized, and the unsatisfactory practice of having the officers and men in two separate Corps was at last abolished, the Royal Engineers and Royal Sappers and Miners being amalgamated, and the following appearing in the *London Gazette* of October 17th, 1856: "The Queen has been graciously pleased to direct that the Corps of Royal Sappers and Miners shall henceforward be denominated the Corps of Royal Engineers."

The Company was not to remain at Home long, however, for it embarked under the command of Captain M. S. Whitmore on the *City of Manchester* on May 18th, 1858, and, sailing for South Africa, disembarked at Algoa Bay on June 5th, whence they proceeded to King Williamstown in British Kaffraria.

On June 2nd the award of the Victoria Cross to Colour-Serjeant Leitch was gazetted.

The Company remained in all nine years in South Africa, spending 20 months at King Williamstown, 5¼ years at Cape Town and 26 months at Grahamstown. While at the latter place, one of the officers—Lieut. H. P. Cole—died of illness on 14th April, 1862. The Company was mainly employed on ordinary R.E. duties and repairs to a number of detached infantry barracks of a temporary nature.

During this period two infantry officers—Captain Henderson of the 10th Foot and Lieut. J. M. Grant of the 85th Regiment—were attached for some time as assistant engineers.

The whole time the Company was in South Africa it was considerably scattered, always having large numbers of detachments at various stations.

The Company quitted the Cape on 16th April, 1867, arriving at Chatham on the 10th June.

On 1st September, 1867, Colour-Serjeant Peter Leitch, V.C., left the Company. He had served in it continuously as Colour-Serjeant for eleven years, being with it at Gibraltar, Chatham, South Africa and Chatham again! One imagines very nearly a record!

In May, 1868, the Company moved out to Wouldham for training for four months, afterwards returning once more to Chatham.

On 8th April, 1869, the Company embarked and proceeded to Camden Fort, Cork, where they settled down for four and a half years, and were mainly employed on the construction of batteries of the then new Moncrief disappearing gun pattern. In December, 1873, they were sent to Aldershot. After two years here, the Company moved to Chatham for a short time, prior to embarking on 24th January, 1876, for Bermuda. Here they remained for nearly three years, moving once more in November, 1878, this time to Malta.

On the 11th May, 1881, the Company re-embarked for Home for

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the last time, proceeding to Chatham, where it became a Depôt Company.

It remained there for four years until, in April, 1885, as a result of reorganization, the Depôt Companies gave up their numbers and were numbered "A" to "G," the 12th Company becoming "A," thus closing the third part of its history.

## PART IV.

### CHAPTER I.

*12th and 23rd (Field) Companies formed.*—In May, 1885, owing to the necessity for more Field Service Units, two new Field Companies were formed and numbered the 12th and 23rd, being stationed at Chatham and Aldershot respectively, their mounted sections coming from the R.E. Troops at Aldershot.

During the next two years the number of the Field Companies was raised to nine, one (the 24th) being in Egypt, and of the remaining eight, the 7th, 11th, 17th and 23rd, being on a war footing of 188 all ranks, known as the Higher Establishment, while the 12th, 26th, 37th and 38th, consisting of 103 all ranks, were on the Lower or Peace Establishment. These eight Companies were known as the 1st and 2nd Field Battalions, and formed part of the 1st and 2nd Army Corps respectively.

The first Commanding Officer was Captain K. MacKean, who did not remain long, however, being succeeded in January, 1886, by Captain J. C. Tyler, the inventor of the tool cart, who was faced by the task of having to organize and train a practically unformed Company. There was at this time no regulation drill for Field Companies, and a modification of the old A and B Troop Drill was usually carried out according to the ideas of the individual officers commanding. Neither had the equipment been standardized, the 12th Company being one of the few units in possession of the "Tyler" tool cart, then somewhat of an innovation.

*Move to the Curragh.*—On August, 19th 1886, the Company, which consisted of three officers (Capt. J. C. Tyler and Lieuts. F. M. Glubb and A. H. Cowie) and about 100 other ranks (30 mounted and 70 dismounted) with 26 troop horses, left Chatham, and, embarking on H.M.S. *Assistance*, arrived at the Curragh on the 22nd, where they settled down in the R.E. Lines on the South side of the Camp, near the racquet court and R.E. Office.

Here they spent a very satisfactory four years in company with the 17th (Field) Company. Both units had a great reputation for smartness, earning high praise from the G.O.C. (General Prince Edward of Saxe-Weimar) who told them that they were the smartest and best of any troops under his command—high praise indeed, as

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the garrison included many crack units of Guards, Horse Artillery, etc.

There was at that period no " Training Grant," and consequently all fieldworks had to be carried out by arrangement with adjacent Irish landlords, useful work, such as bridging the Liffey, road-making, necessary demolitions, etc., being done as far as possible. Much combined training with Infantry and other arms was also carried out, a practice not universally adopted at other Home stations for some years.

In the early part of 1890 when various light railways were being laid in Ireland, several N.C.O.s from the Company were employed in their construction, an experience which was for them an exceedingly useful, and, from all accounts, an extremely enjoyable, one.

*Move to Aldershot.*—In October, 1890, the Company, under the command of Captain G. K. Scott-Moncrieff, moved to Aldershot, going by sea from Dublin to Portsmouth, whence the mounted section went by road and the dismounted by train. At first the Company found themselves quartered in huts in Stanhope Lines which had long since been condemned, and which were so bad that a formal complaint was made to the G.O.C. (Sir Evelyn Wood). As a result of this the Company was moved into Badajoz Barracks where they found ample and comfortable quarters, the barracks being shared by the Cameronians, with whom they became very good friends.

The lesson of combined training had not yet been learnt at Aldershot, and all fieldworks training was carried out by the Company at Pyestock.

*Cycling Club.*—It was at this time that a cycling club was formed in the Company. Bicycles were then very new toys, such things as pneumatic tyres being unknown, and it was considered *infra dig.* for an officer to ride them even in plain clothes! The club was, however, well supported and was financed by the Canteen Fund.

In addition also to their being used for pleasure, they were used greatly during training for such work as advanced guards, engineer reconnaissances, etc. This cycling club was the forerunner of the present equipment of bicycles in a Field Company and must have been one of the earliest instances of their being used for tactical or engineer work.

In July, 1891, the Company took part in a General Parade, when H.M. Queen Victoria reviewed the troops at Aldershot.

During this period the Company won the six-horse-team driving competition open to the Corps at the sports held in R.E. Week.

*Move to Woking.*—On May 24th, 1892 (the Queen's birthday) the Company moved to Woking where they were employed converting the Prison into barracks, married quarters, etc. Owing to lack of accommodation the Company was the whole time under canvas in the Prison Yard.

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The same year the new Lee-Metford Rifle, of which but few people understood the handling, was issued. The Company were lucky, however, in having an officer (Lieut. C. O. C. Bowen) who thoroughly understood it, and consequently fired the best practices among the R.E. Troops that year.

At the R.E. Sports in May, 1893, they again won the Driving competition and tug-of-war.

The Company went to the 1893 manœuvres which were held on the Wiltshire Downs, and were a good deal broken up, the mounted section being used as general transport, and headquarters of the Company being in Uffington Park.

When the work at Woking was completed the Company returned to Aldershot for some fifteen months, being inspected by H.R.H. the Duke of Connaught on the Long Valley on the 30th April, 1894, and taking part in a Grand Review held by Queen Victoria on the 17th May, subsequently proceeding to Shorncliffe on 23rd October. Here they remained for three years, taking part in the 1895 manœuvres near Ashford, and those in 1896 and 1897 near Minster and Arundel, and returning once more to Aldershot, the dismounted on the 14th and the mounted on the 16th October, 1897.

On July 7th, 1898, there was a review by Queen Victoria on Laffan's Plain in which the Company took part. On July 30th the Company went off on manœuvres and established its headquarters at Stockton Park on Salisbury Plain, being chiefly employed on water supply for the various manœuvre camps and returning to Aldershot on September 24th.

## CHAPTER II.

### SOUTH AFRICAN WAR.

*Personnel.*—The outbreak of the South African War in 1899 found the Company still at Aldershot, where it was mobilized on 9th October. In addition to the officers and men already with it, Major A. Graham Thomson, Lieuts. Craven and MacDonald and 136 Reservists joined, and Lieut. Elsner, R.A.M.C., was attached, bringing the strength up to 6 officers, and 1 attached, and 207 other ranks, the officers being Major A. Graham Thomson commanding, Captain A. L. Schrieber and Lieuts. A. J. Craven, R. H. MacDonald, J. R. White and J. J. H. Nation, and Lieut. O. W. A. Elsner, R.A.M.C., attached.

The Company left Aldershot at 8 p.m. on November 7th and embarked at Liverpool the next day on S.S. *Bavarian* along with Lieut.-Colonel A. C. Foley (C.R.E., 3rd Division), his assistant, Captain P. G. Grant, and six foreign military attachés.

On November 10th the Dublin Fusiliers and Connaught Rangers came on board at Queenstown, the ships having an enthusiastic send off from the inhabitants and the other ships in the harbour.

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*Arrival in Africa.*—The Company disembarked at East London on 3rd December and drew their saddlery and extra transport, consisting of 48 Scotch carts and one buck waggon, the same day, leaving in two trains for Putters Kraal, where they joined Major-General Sir W. Gatacre's (3rd) Division, the next day.

On 5th and 6th 127 mules and 18 horses arrived, but the drivers did not come until the 7th, when the transport at once started getting ready to take the field.

On the night of the 7th a conference of Officers Commanding units was called and the plan of operations for an attack on Stormberg was given out and maps issued. On the 8th, there being a change in the plan of operations, another conference was called and fresh orders issued.

*Action at Stormberg.*—On the morning of the 9th, Reveille being at 4 a.m., camp was struck and the transport loaded up. The latter, under the command of Lieut. White, moved by march route to Molteno; the dismounted, except Lieut. Nation and 13 sappers, left at Putters Kraal for defence works, entrained at 3.30 p.m. and proceeded to Molteno in open trucks, reaching that station at 6.40 p.m.

At 9.30 p.m. Major Graham Thomson and Lieut. Craven and No. 1 Section (53 rank and file) marched off as escort to the ammunition column with the artillery, the remainder of the Company staying at Molteno, under Captain Schrieber, to construct defences.

Staff arrangements for the march were very much lacking, and after about two hours some Mounted Infantry cut through the column, causing considerable confusion, as a result of which the Company, instead of being behind the second Battery, found themselves behind the Ammunition Column, where they remained until the close of the action. The column was also led wrong, and, after taking the wrong road, only arrived in the vicinity of Stormberg at 4 a.m., being off the map issued for the operation, and having had practically no halts all night.

There appeared to be no orders, and when firing commenced about 4.20 a.m. the R.E. and S.A.A. Column found themselves isolated with but a very vague idea as to where the infantry were actually engaged, and without any maps of the country. The infantry were, however, eventually located by the C.R.E. who had climbed a hill near by, and the S.A.A. was escorted up to the firing line, which at this point was composed of Northumberland Fusiliers and Irish Rifles. At about 8.30 a.m. the order to retire on Molteno was received. It was not then realized that 600 of the small force had been left behind, killed, wounded or prisoners, as well as two guns lost; such however was the case.

On the return march men of various regiments, without their officers, streamed past, the Boers giving evidence of their presence

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by shelling the road. No damage was done, however, as none of the shrapnel burst in the air. One native policeman riding up to the O.C. 12th Field Company remarked " Boer shells no damn good, Sir ! " The few snipers who had come out from Molteno to enjoy the sport seemed equally unsuccessful ! The sole Company casualty was one mule slightly wounded.

Molteno was reached about 11.30 a.m. and about 6 p.m. the whole Company entrained for Cypherghat.

The absence of any preliminary reconnaissance, the bringing of men worn out with marching all night right into the enemy's position without apparently knowing where it was (the leading troops were in fours when fired on) and the complete absence of orders would appear to make success in such an undertaking almost an impossibility.

The party under Lieut. Nation had received a wire on the 10th warning them that a disaster had occurred and ordering an immediate retirement. This order was, however, countermanded just in time. Meanwhile the defences of the camp had been considerably strengthened and several wells sunk with diamond borers.

*Sterkstroom.*—On the 15th this detachment rejoined Headquarters, which had moved to Sterkstroom on December 11th.

Here the Headquarters of the 3rd Division and of the 12th Company remained till March 7th, 1900, during which time they were mainly engaged in constructing a large number of redoubts and other field defences, enlarging the school house in the village and turning it into a hospital, improving roads and carrying out water supply, including sinking three deep wells with diamond borers. Two dams were also constructed in a *dongha* near the camp to form a horses' drinking and men's washing place. These were, however, being continually washed away by sudden heavy rains.

Enteric was rife in Sterkstroom, chiefly owing to the somewhat primitive sanitary conditions, all latrines being open and flies abounding in all cookhouses and tents where food was eaten.

The climatic conditions at this time of the year were also particularly trying, as it was very cold and very often raining hard during the night, while it was always boiling hot during the day.

The usual working hours were about 5 to 7 a.m., 8 a.m. to 12.30 p.m. and 2 to 5.30 p.m.

In addition to the ordinary work there were many detachments, nearly half the Company being always out.

*Detachments.*—Lieut. MacDonald and 50 sappers carried out water supply and construction of field defences at Penhoek from 20th December to 1st January, 1900. On January 1st another detachment, under Lieut. White, proceeded to Bushman's Hoek to carry on work on defences there previously carried out by the 29th Company. On the 3rd an attack was made on them by the Boers, who, after

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surrounding Molteno, advanced on and shelled Bushman's Hoek. Half a Battalion of the Royal Scots and a Battery of Artillery were sent up as reinforcements, and in spite of somewhat inaccurate practice made by our guns on their positions on Cypherghat hill, the enemy retired.

On the 8th a column under the command of Colonel Smith Dorrien, consisting of 1 Battery R.F.A., 25 sappers under Lieut. White, half a Battalion of the Derbyshire Regiment and about 100 M.I. carried out a reconnaissance in force towards Stormberg, but, although a few Boers were met and a little desultory firing took place, nothing of importance occurred.

On January 20th a party of 40 sappers under Captain Schrieber and Lieut. Craven, and again on the 24th, 25 sappers and 400 of the R.I.R., went out to the Looperberg and constructed defences, the former party remaining until February 5th.

On January 27th Lieut. MacDonald and about 20 men of No. 2 Section proceeded to Penhoek, where they remained constructing defences until Lieut. MacDonald with Serjt. (afterwards C.S.M.) Field and 11 N.C.O.s and men joined Brabant's Colonial Division on February 21st, Lieut. Nation then taking charge of the remainder of the detachment.

Lieut. MacDonald's detachment came in for a lot of hard work and several engagements while serving with the Colonials, Driver Wakefield being killed in action at Wepener on April 24th, 1900.

On February 7th another attack was carried out by the enemy, this time on Penhoek and Bird River. A party of 6 sappers under Lieut. Nation went out with half a Battalion of R.I.R. and some Irregulars, with guns, and, after advancing across country and shelling the enemy, the force occupied Bird River without much opposition, returning to camp in the evening.

On February 23rd Lieut. Craven with a detachment accompanied a reconnaissance made by General Gatacre towards Stormberg.

On the 24th Captain Schrieber and a detachment of 17 sappers proceeded to join General Brabant's force at Dordrecht, where there had been some sharp fighting during the previous week. They were joined on the 26th by Lieut. Nation and 18 more men, a redoubt on the heights west of the town and other defence works being subsequently constructed.

*Action at Labuschaynes Nek.*—Major Cedric Maxwell, R.E., finding himself in command (General Brabant being away temporarily) decided to carry out an attack on the Boer positions at Labuschaynes Nek. The force, consisting of about 1,000 M.I., two 15-pdrs., two 7-pdrs., 35 sappers with 2 officers and some Royal Scots, advanced at 12.30 a.m. on the morning of Sunday, March 4th, and, having captured Spitz Kop by surprise, arrived in position about 4 a.m., soon after which the shelling of the Boer position was begun. A good

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deal of general fighting then took place on the forward slopes of the kopje, where there was very little cover, the Royal Scots who were in this position having a very hard time.

After constructing a few defences, the Sappers returned to camp about 4 p.m. They were, however, ordered out again at 6.30 p.m., arriving at the scene of action at 10.30. Here they did extremely useful work constructing gun pits, breastworks and *schantzes* under fire from about 5 a.m. onwards.

*Captain Schrieber awarded D.S.O.*—There was meanwhile a force of the enemy occupying a small bit of high ground, known as " the Fort," which completely commanded the ridge held by us and which enabled them to enfilade our position and give us no little trouble. A brilliant charge by 15 sappers under Captain Schrieber and an officer and 15 men of the Border Horse, however, carried the position and entirely relieved the situation, the Boers retreating precipitately, leaving their dead and wounded behind. In this action both officers were wounded. After this practically no serious opposition was encountered and the sappers returned to Dordrecht about 6.30 p.m. Captain Schrieber subsequently received the Distinguished Service Order.

*Advance to Orange Free State.*—On March 6th Stormberg was occupied, Lieut. Craven and No. 1 Section moving there and starting the repair of the railway line ; the Dordrecht detachment returning to Headquarters the same day.

On March 7th the general advance to the Orange Free State was begun, the Company marching that day to Cypherghat, about 18 miles, moving on the next day to Molteno where they entrained for Stormberg.

*Repair of Railway started.*—On the 9th the Company was fully employed repairing the line up to Bethulie, on the deviation at Lienfontein where the bridge was blown up, replacing about $\frac{1}{4}$ of a mile of rails turned over by the Boers, and repairing Wonderboom Bridge, enabling the first train to enter Burghersdorp at 6 p.m.

Between the 10th and the 13th two bridges were repaired and a deviation of considerable size at Olive Siding was completed and Bethulie reached. The Boers had been holding the North bank that morning when the Company arrived, but though five of the eight spans of the railway bridge were destroyed, the road bridge was still intact, enabling the transport to march in as soon as the enemy retired.

The next day (March 14th) the Company started work on the repair of the line from Albert Junction to Aliwal North. The first serious obstacle that was met was the bridge over Stormberg Spruit, consisting of 3 spans of 150 feet, each of which was badly damaged. The work which mainly consisted of building three crib piers, one of which was 36 feet high, was carried out by a detachment

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under Lieut. Nation assisted by 50 kaffirs. This was finished on the 16th and the construction train ran on into Aliwal North, where a great reception was accorded them by the townspeople.

On the 18th the Company proceeded once more to Bethulie to construct a railway deviation to the road bridge. This work was of very considerable extent, requiring one-half to three-quarters of a mile of line on either bank of the river, and large working parties, mainly of the Royal Scots, were employed. The work on the deviations on both banks was completed by the 26th, when the Railway Pioneer Regiment arrived and took over the work, the Company proceeding to Springfontein, dismounted, by rail, the transport marching and arriving on the 29th, except the Company pontoons which had been left in the Orange River at Bethulie for the Railway Pioneers.

*Bloemfontein.*—On April 1st the Company—less Lieut. White and No. 3 Section, who rejoined on the 11th—left for Bloemfontein, the dismounted arriving on the 2nd and the transport moving by march route arriving on the 10th. The Company camped on a hill about three miles south east of the town.

While at Bloemfontein, the Company was employed on water supply, road making and defences. Detachments of 20 men each, under Lieuts. Nation and Craven respectively, also proceeded to Kaffir River and Riet River Bridges for the construction of defence works, from April the 11th until the 14th.

*Company join 11th Division.*—On the 21st the Company proceeded to join General Pole Carew's 11th Division at Springfield, where they found themselves with the 18th Brigade.

While at Bloemfontein, all the second line mules had been taken away, and when orders were received to march back to Springfield, sufficient mules were not forthcoming, and those that were drawn from Remounts were in such poor condition that many collapsed on the march, necessitating part of the equipment being left at Bloemfontein and some at Springfield.

At 5.45 a.m. on the morning of the 22nd the Company marched with the 18th Brigade, and later received orders to join the Headquarters of the Division at Karriefontein, which was reached after a 20-mile march at about 5.30 p.m.

A detachment had meanwhile been sent with the M.I. to cut drifts in the Modder River. Major Graham Thomson met the M.I. and their Commanding Officer asking him to tell his sappers to " gallop up after us ! " not realizing that they were on foot. The sappers consequently had a fast 15-mile march there and back, without result, however, as the Boers had retreated.

Until the 26th the Company was working with the 11th Division in the neighbourhood of Modder River, cutting drifts, etc., after

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which date the whole division returned *via* Paardeskraal and Karriefontein to Bloemfontein, which they reached on the 29th.

April 30th was spent by the Company in refitting with clothing, equipment and transport. Although R.E. Companies no longer had any pack animals, the 12th retained their pack saddlery, which they found most useful with advance guards and working-parties in hilly country.

The next day, May 1st, the Company started on the first stage towards Pretoria, marching to Karee Siding, 22 miles, a very fine performance, as very few men fell out.

*Volunteer Section joins.*—On the 2nd Lieut. Pollard and 23 rank and file of the Newcastle Volunteers joined the Company. They were an exceptionally good lot of men and were paid the compliment of being, before very long, drafted into the sections of the Company, instead of, as in most other units, being kept as a separate "volunteer" section.

60 Basutos with 2 headmen and 2 gangers also joined the Company. These men were invaluable for work, especially when it occurred on the march. They remained with the Company until July 11th, when they were forced by their chief to return home with him.

On the evening of May 2nd the Company received orders to march with the Guards and make good two drifts over the Karee River. The Guards were, however, not informed of this and there was, moreover, no information as to the position of the drifts.

The Company moved off, with two battalions of the Coldstream Guards, and bivouacked right in the open where it was bitterly cold. The next morning Major Graham Thomson and Lieut. Craven rode out ahead to look for the drifts, imagining that the front had been cleared by the M.I. When they arrived within about 180 yards of the drift, which was over a thickly wooded dongha, they were suddenly shouted at to "Kom here," and discovered some 8 "Zarps" in the bushes. These at once started firing, but did no damage except wounding the Major's mare in the stifle, in spite of which, however, she managed to carry him back to the camp. The Company then proceeded to the drift from which the enemy had by this time retreated.

Practically no further opposition was encountered and Brandfort was occupied about 5 p.m. that evening.

*Action at Vet River.*—On the 5th, the Company having rested the previous day, the march was continued another 20 miles to the Vet River, where the enemy was met in some little strength, an artillery duel ensuing till dark, when the force encamped, with the Boers still holding the North bank.

The next day, the enemy having retreated once more, the force advanced to Smaldeel, a new drift being cut in the Vet River, and the old one, after much work, being repaired.

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As the railway bridge was also completely destroyed, first Lieut. Craven and subsequently Lieut. White remained behind with a Battalion of infantry and about 1,000 Basutos to work on the deviation. There was also a considerable amount of repair necessary on the railway between Vet River and Smaldeel, which was carried out.

On the 9th the Company marched to Welgelegen Siding, where a drift was repaired. The next day the Zaand River was reached, where slight opposition was met, though after a little shelling the Division was able to cross and camp some 6 miles further on, the Company remaining at the river to improve the drift and to construct a new road from it, which work was completed late that night.

The men had by this time got thoroughly hardened and thought nothing of a 20-mile march with perhaps 3 or 4 hours' work, during, or at the end of it. One section usually marched with the Advance Guard, the remainder marching behind the leading battalion of the Main Body.

The next day another long march was made to Geneva Siding—some 26 miles, in which the men kept up very well.

*Kroonstadt.*—On May 12th the Division started once more at 6 a.m., expecting to meet determined resistance. None, however, was encountered, and Kroonstadt was entered about 2 p.m. Here the Division marched past the C.-in-C., Lord Roberts, the Company eliciting some very complimentary remarks on the fine style of its marching after a long and trying day.

The Company remained at Kroonstadt for 8 days, during which time some extremely heavy deviation work was carried out, reliefs of infantry working day and night. Owing to the amount of rock near the town, a very great deal of blasting had to be done, for some of which explosive which the Boers had left in Brandfort was used.

On the 22nd the march was continued to Hoening Siding, and the next day the Rhenoster River was crossed, drifts being repaired with the help of the 9th Company, who were also accompanying the Division.

On the 24th the Company remained at the Drift until all the transport was over, when they marched on and rejoined the Division about 8 p.m., after a 15-mile march.

The next day Grootvlei was reached and an abundance of excellent water found, and again on the 26th with the help of the 9th Company the drift at Taibosch Spruit was repaired.

On May 27th the Vaal River was crossed at Vieljoen's Drift by means of the drift and a pont worked by the 9th and 12th Field Companies. Lord Roberts and his staff rode across the drift that day.

On the 28th the march was continued to the Klip River, and the day after to Elandsfontein, where a great deal of delay was caused

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in the morning by the 4·7 naval guns, which, starting before their proper time, went over an existing bridge over the Klip River, which they smashed, having to be dug out by the sappers. The bridge had then to be demolished and a drift cut by the 9th and 12th Companies while a new trestle bridge was erected by the 12th, over which the 7th and 11th Divisions crossed. Nor did this bridge escape scatheless, as the 7th Division left no staff officer to regulate the traffic and, owing to some reckless driving, one of the trestles was smashed up, a new one having to be erected.

*Railway blown up.*—The same day Lieut. Craven and 4 sappers went out with Henry's M.I. and very successfully blew up rails on the Natal line in four places, to prevent trains getting away, thereby enabling six to be captured at Elandsfontein junction.

*Johannesburg.*—On May 31st Johannesburg was entered, the 11th Division marching past Lord Roberts and camping at Orange Grove, about 4 miles north of the town, the 18th Brigade and 12th Company's camps being unfortunately situated in the vicinity of small-pox and leper hospitals!

The Column rested on June 1st and 2nd, and on the 3rd marched to Lanfontein, about 11 miles to the north.

The next day the march was continued and the Company were ordered to make a drift for the crossing of the 11th Division. They were, however, sent off along the wrong road, and, having made a drift by which the 7th Division crossed, they returned 2 miles east and made several drifts, over which the 11th Division and the baggage went.

*Action before Pretoria.*—When the Column arrived within six miles of Pretoria, the enemy, who were occupying the ridge round the town, put up a strong opposition. The naval guns thereupon shelled two of the forts, while the infantry advanced, after a sharp encounter and a considerable amount of firing, to within about three miles of the town, the 12th Company being just in rear of the 4·7 and 5-inch guns.

*Pretoria entered.*—On the 5th June Pretoria was entered, the column (7th and 11th Divisions) marching past Lord Roberts in the square, the 12th Company being once more complimented on the way they marched past.

On the 6th Lieut. Craven and 12 sappers went out in a train to Waterval prisoners' camp, and came under heavy shell fire, as a result of which the Dutch driver and fireman bolted, being replaced by Sappers Gilham and Pedley, the former driving and being slightly wounded. After proceeding under fire and picking up as many prisoners as possible, the train returned to Pretoria, going out once more to pick up stragglers—altogether a very plucky performance.

On the 7th the 11th Division moved to Silverton, remaining there till the 10th.

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*Action at Diamond Hill.*—On the 11th the 12th Company moved out with the naval guns and took up a position from which the enemy on Diamond Hill were shelled in a somewhat desultory manner, though the Divisions on the right and left (Ian Hamilton and French) had a good deal of fighting.

The next day the Company marched off with the Guards Brigade in support of Ian Hamilton, and made good several drifts. A good deal of desultory firing took place, but little serious fighting, the Guards carrying the position in the evening, crossing a bridge constructed by the Company during the day.

On the 14th the Company constructed a bridge at Mark's Drift, and, with the rest of the Division, returned to Pretoria the next day.

On the 19th Lieuts. Craven and White, with a detachment of sappers and some 600 Scots Guards, proceeded to Waterval prisoners' camp to take down the shelters there. These were subsequently re-erected at Erstefabriken.

On the 21st the 11th Division moved to Mark's Drift near Erstefabriken, and on the 23rd the Guards Brigade, accompanied by Lieuts. Nation and Pollard with 40 men, moved to Donker's Kop, the Headquarters of the Company remaining at Erstefabriken.

The Company remained situated thus for a month, during which time a considerable amount of work was done on hutments, roads, water supply and defences. A few minor engagements also took place in the neighbourhood, in which, however, the Company took no part.

On July 23rd the Company rejoined Headquarters of the 11th Division and Guards Brigade at Donker's Kop, Lieut. Craven and one section being with the 18th Brigade, the march to Komatie Poort beginning the next day with a move of 15 miles to Bronkhurst Spruit.

On the 25th the Division marched to Hartebestefontein, the Company making good drifts over Wilge River and building a bridge to take the 5-in. guns, and marching the next day to Brugspruit where they remained until August 2nd, working on defences, water supply and the construction of some eight trucks for running to Middleburg to connect with General French's force.

On the 27th July Lieut. Craven's section continued with the 18th Brigade to Balmoral, where similar defences and water supply were carried out.

On the 30th Lieut. Nation and No. 2 Section proceeded to Olifants River with some battalions of Guards and some guns. Roadmaking, water supply and defences were again the main work.

On August 3rd the Company, with the Scots Guards, naval guns and ammunition column moved on to Olifants River, marching the day after to Middleburg, No. 2 Section remaining behind for work

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on bridges, *schantzes* and other defences until the 20th, when they, too, moved on to Middleburg.

Here the Company's work was again on water supply and defences, a large amount of work being done in addition on the hutments and hospital.

On the 22nd the Company moved with the 18th Brigade to Pan, and on the 23rd to Wonderfontein, drifts being made good on the road and water supply improved.

*Action at Belfast.*—On the 24th a further advance was made to Belfast, where the enemy was met and exerted some opposition, the Column finally camping by the station. During the next two days trenches were dug and breastworks erected by the Company under heavy shell and musketry fire. The former was usually very accurate though not well burst. On the 25th a tracing tape was cut by a direct hit as it was being laid out, and on the 26th another shell hit the back of a trench in which the 12th Company and the Royal Scots were working, but luckily both burst in the ground. A considerable amount of unnecessary rifle fire was drawn on the working parties by officers riding up on horseback and standing in most conspicuous positions watching the work.

*Serjt. Hughes awarded D.C.M.*—During this period Serjt. J. Hughes was conspicuous for his coolness and devotion to duty while working under fire. He was subsequently awarded the Medal for Distinguished Conduct in the Field.

On the 27th a small advance was made, the Company moving with the Guards and 18th Brigades.

The next day the 18th Brigade, accompanied by the 12th Company, made a flank march to Swarz Kopjes to support General French, drifts being made by the Company, and the march being continued during the next two days to Helvetia, where the Column for the time being joined forces with General Buller, and then to Waterval Onder. The roads on this march were exceedingly bad and very steep, and even the small amount of sniping and desultory firing which went on gave a certain amount of trouble.

The force remained at Waterval Onder until the 9th Sept., the Company meanwhile improving the roads which were impassable for heavy traffic, building a suspension bridge across Elands River and carrying out water supply.

On the 10th the Column moved on to Nooitgedacht, where there had been a large prisoners' camp. The work on the march was very heavy, as the roads and drifts were extremely bad, similar work being also encountered the next day on the march to Godwan.

*Very trying marches.*—The next day's march to Kaapsche Hoop and Devil's Kantoor was exceedingly trying, as the road was as steep as 1 in 4 in many places, and two of the Company waggons had to be abandoned, " double banking " having to be resorted to

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with the 2nd line teams, many of the waggons not arriving till early the next morning.

On the 15th, 16th and 17th the march was continued to North Kaap Station, on the Barberton Line. The descent was as steep as the ascent had been on the previous days and several waggons were upset. Very heavy work was again encountered on the roads, General Pole-Carew expressing his appreciation of the work done by the men, and presenting them with a case of beer!

On the march to Kaapmuiden, which was reached on the 20th, more bridges were found destroyed and a large amount of locomotives and rolling stock were captured, a party of engine drivers and fitters being sent on ahead to get them in running order.

Lieut. Nation and about 25 sappers were left behind under the C.R.E., when the march was continued, to repair Hector's Spruit Bridge at Malalene. A pumping station was also repaired here and the march continued to Komatie Poort which was reached on the 24th September.

The last three days of this march, when water was very scarce and roads bad, had been very arduous for a force accompanied by heavy guns and transport and, had the Boers made any stand, there is no doubt that the march would only have been accomplished with heavy loss.

As some Australian M.I. had been sent on 48 hours ahead to demand the surrender of Komatie, the enemy had had plenty of time in which to effect demolitions, but had done very little, as they had been running a great number of trains to the Portuguese border and consequently a large amount of rolling stock was captured, most of it undamaged.

The railway bridge over the river at Komatie had been prepared for demolition, but no charges placed, as was discovered by C.S.M. Skinner and Serjt. Hughes, who swam out and opened up the cavities which had been cut in the piers to receive the explosives.

The section under Lieut. Nation remained at Hector's Spruit, repairing the bridge and carrying out water supply until October 2nd, when they rejoined the Company at Komatie Poort. On October 1st there was a bad railway accident at Hector's Spruit Station, in which Driver Pearce was killed and Sapper Phillips injured. Both belonged to the 12th Company.

*(To be continued.)*

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# HISTORY OF THE 12TH COMPANY, ROYAL ENGINEERS.

MAP 1.

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## *PROFESSIONAL NOTES.*

### AN IMPROVISED FLOATING FOOTBRIDGE.

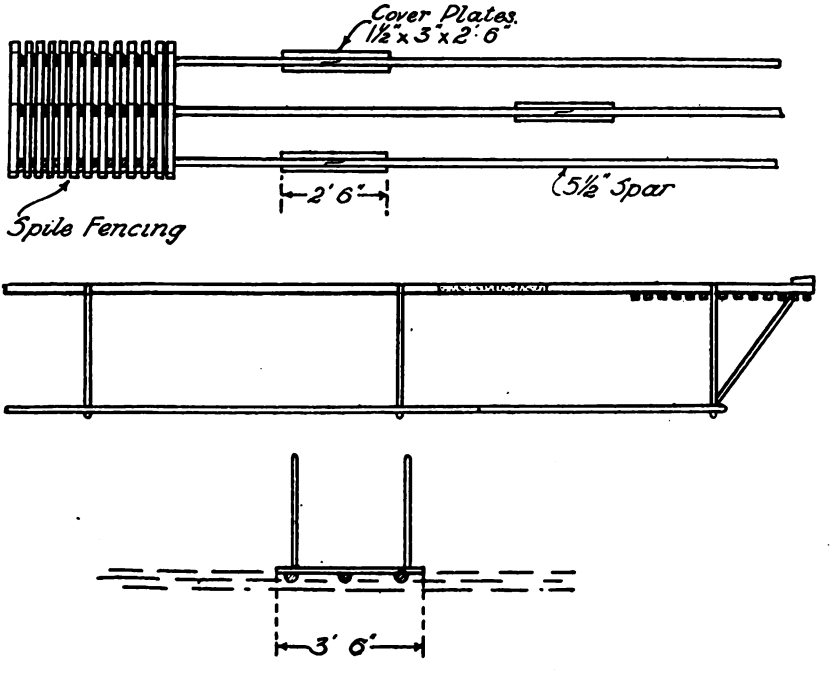
*(Communicated by the R.E. Board.)*

THE bridge described below was designed by the French Engineers at Montpelier, and has recently been tried at Chatham. A detailed description appears in the October number of the *Revue du Génie Militaire.*

Though subject to limitations, it possesses the advantage of being made of materials which can frequently be found locally. Its construction is simple and rapid. No rope is required.

It is, however, not an assault bridge, being too heavy and rigid. It is unsuitable for currents over three knots. Its buoyancy is only moderate.

Briefly, the bridge consists of a footway of light timber fencing supported on three rows of floating spars.

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The fencing can be constructed of round spars, 1 in. in diameter, or of timber split from young trees, averaging some ¾ in. by 1½ in. in cross section, by 3 to 4 ft. in length. These are held together by three rows of double wiring, the wires (about 16 S.W.G.) being twisted together between each piece. The fencing can be rolled up, and is then very portable. Spile fencing of split chestnut, such as is now extensively made and used, is very applicable.

*Construction of Bridge.*—Three parallel rows of spars of 5½-in. mean diameter are first laid out at 1 ft. 3 in. centres, breaking joint. The joints are halved together and further strengthened by wooden cover plates, 3 in. by 1½ in. by 2 ft. 6 in. A light batten is nailed across the spars at each end as a shore transom. The fencing is then unrolled along the spars and nailed every 3 ft. Handrail posts are fitted into auger holes in the outer spars.

*Time of Construction.*—Two men can make 30 ft. of bridge in about 40 minutes, assuming that the material is available at site.

*Method of Launching.*—The bridge weighs about 26 lbs. per foot run. Two men every 6 ft. are sufficient to lift it bodily and launch. It can also be swung or paddled with shovels.

*Buoyancy.*—The bridge is capable of supporting armed men at 15-ft. intervals.

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## IMPORTANT WORKS EXECUTED BY THE BUILDINGS AND ROADS BRANCH OF THE MILITARY ENGINEERING SERVICES, INDIA, 1923–24.

THE more important works, executed by the Buildings and Roads Branch of the Military Engineering Services (till recently known as the Military Works Services) during the year 1923–24, have included the following :—

### A.—FRONTIER ROADS.

The most important road work of the year has been the completion of the last link of the road through the heart of the Mahsud country in Waziristan, from the Tochi valley on the north to the plains of the Derajat on the south.

A hutted camp is now being constructed at Razmak, where a garrison of regular troops will always be within a few miles of Makin and Kaniguram, the two most important villages of the Mahsuds.

The garrison will thus be living in a comparatively temperate climate, at some 5,000 to 6,000 feet above the sea, instead of being situated as heretofore in the torrid plains and foot-hills of Bannu and Derajat Districts.

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By means of the new "Circular Waziristan Road"—as it may be called—troops from this garrison can move rapidly, with their mechanical transport, to any of the various fortified points on the road, and thence act promptly against any hostile gatherings of tribesmen. It also affords the tribesmen and traders with a traffic route, and locally-owned motor-cars are to be seen on the road in increasing numbers.

The road is thus of a very great political and economic value and represents a change in the conditions of Waziristan, that is bound to have very far-reaching effects on the Frontier tribesmen.

In addition to the construction of the last link of the road itself—from Sararogha to Razmak—the other sections of the road, from Isha in the Tochi, on the north, to Khirgi, Tank and on to Dera Ismail Khan, on the south, have been improved to increase their capacity for mechanical transport, during the year. A large bridge of nine spans (total length 915 ft.) across the Tochi river at Tal is now rapidly nearing completion. Plans have been prepared for the rebuilding of another large bridge at Jandola across the Takki Zam, to improve the reliability of communications towards the southern end of the road.

Another road is being constructed from Jandola to Sarwakai, on the southern side of the Mahsud country, and this entails some heavy work where the route passes through a gorge known as the Shahur Tangi.

Intimately connected with the roads are the fortified posts on them which contain garrisons of irregular troops, recruited from frontier tribesmen, and forming a corps that is known as the "Waziristan Scouts." These "Scouts' Posts" are now nearly completed at most points on the main Circular Waziristan Road, but those on the Jandola-Sarwakai, and a new Post at Jandola, are only just begun.

Military labour—Sapper and Miner Companies and Indian Pioneer Battalions—has been very largely employed, and without their assistance the work could not have been completed as rapidly as it has been, as the work of the Indian or Pathan contractor in this inhospitable tract of country is very slow, uncertain and ineffective, especially where heavy cutting or tunnelling and building of walls or posts has to be undertaken, as well as being very expensive.

The following troops were employed, and it is interesting to note that this is the largest concentration of technical troops ever known in India hitherto :—

*Sappers and Miners—*

Nos. 3 and 5 Companies, K.G.O. Bengal.
Nos. 12 and 13 Companies, Q.V.O., Madras.
Nos. 19, 20, 21, 23 Companies, Royal Bombay.

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*Pioneer Battalions—*

1/1 and 1/2 Madras Pioneers.
1st, 2nd and 3rd Sikh Pioneers.
4th and 10th Bombay Pioneers
and 4th Hazara Pioneers.

Altogether some 133 lacs (about £950,000) were expected to be spent during the financial year 1923–24 on the above frontier roads.

B.—TRAINING AND EDUCATIONAL INSTITUTIONS.

A Machine-gun School and the Indian centre for Armoured Car units are now located at Ahmednagar, and some Rs. 1·29 lacs have been spent in altering the old R.F.A. Lines there to make them suitable for the above establishments.

At Belgaum in South India, where the Senior Officers' School and the Indian Army School of Education have been situated for some three years, it is now proposed to locate the British Army School of Education also, which has hitherto been at Wellington.

In order to do this, the R.F.A. barracks at Belgaum are being altered for this new purpose at a cost of some Rs. 1·61 lacs, of which some Rs. ·75 lacs were spent during the year.

In order to complete the accommodation required for the Senior Officers' School, some Rs. 1·83 lacs were also spent during the year at Belgaum.

C.—I.A.S.C. WORKS.

An important Base Supply Depôt has been organized at Lahore and Rs. 24·69 lacs were spent during the year in building sheds and other accommodation there in connection with this project.

D.—ORDNANCE—ARSENALS AND DEPÔTS.

In consequence of the arrangements for the reorganization of the clothing supply for the Army in India a good deal of work has been carried out at the large Clothing Depôt at Shahjehanpur in the United Provinces, amounting to Rs. 5·31 lacs. For similar reasons clothing storage accommodation at the Kirkee Depôt has been sanctioned at a cost of Rs. 1·15 lacs, of which about half has been constructed during 1923–24.

A large scheme, amounting to Rs. 15·07 lacs for the improvement of Rawalpindi Arsenal, was sanctioned, and work has been done during the year to the value of Rs. 12·08 lacs.

Quetta Arsenal has also been enlarged and altered, some Rs. 1·80 lacs having been spent during the year, out of a total estimated amount of Rs. 2·60 lacs.

E.—DEFENCES.

As the result of the recent murders of officers and ladies in cantonments near the N.W. Frontier, schemes for providing barbed

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wire perimeter fences, clearing areas of trees and undergrowth, and providing electric lights for these defences, have been carried out at Kohat and Bannu, and similar arrangements at Peshawar have been improved during the year at a total cost of Rs. 3·13 lacs.

Two fortified posts for large detached picquets have been constructed in the Khyber, one at Shahgai and one overlooking the Afghan frontier, where the Khyber Road crosses it, costing together about Rs. 1·24 lacs.

## F.—Auxiliary Force (India).

Projects for the construction of Headquarter buildings for the Burma Railways Battalion at Rangoon and for the Calcutta Scottish Battalion at Calcutta were sanctioned, and Rs. ·30 and ·40 lacs, respectively, were to be spent during the year.

Eleven other estimates for providing quarters for Instructors, and also, in some cases, armouries, offices and ranges, in many distant stations such as Dibrugarh, Calicut, Cochin and Maymyo (in Burma) were sanctioned and funds amounting to Rs. 2·19 lacs were to be expended during the year on them.

## G.—Accommodation for Officers.

The Government of India have accepted the policy of providing hostels for the accommodation of British Officers at stations where suitable accommodation is not available locally. In all, five such hostels have been completed, at Chaklala, Peshawar, Kohat, Quetta, Lahore Cantonments, or are under construction.

These hostels consist of a set of public rooms—dining-room, reading-room, card-room, billiard-room, etc.—with a varying number of "unit" quarters, from 23 to 32 units, according to the local requirements of the station.

Each "unit" quarter consists of a bed-sitting room, dressing-room and bathroom, with a 10-ft. verandah all round the block. The dimensions of the rooms vary according to location, that is, at a "very hot plains" station, "normal plains" station, "semi-hill" station, or "hill" station. So far, however, no hostel has been built at, or contemplated for, a hill station.

Each unmarried Captain or Subaltern is permitted to occupy one unit quarter, while an unmarried Field Officer may occupy two; a married Officer is given two or three unit quarters, according to the size of his family.

Each unit quarter is completed with water supply fittings and electric lights, fans also where necessary, and essential furniture.

At certain stations, where the provision of a hostel is not clearly justified, but where quarters are necessary, unit quarters are provided, for single officers only, adjacent to an existing Officers' Mess;

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thus releasing bungalows in the station for the use of married officers.

The provision of bungalows for married officers is also provided at stations where these are clearly necessary.

### H.—ACCOMMODATION FOR BRITISH TROOPS.

The evacuation by the Military, and the sale of the Fort and surrounding area to the Civil Authorities, necessitated the provision of accommodation for one Company of British Infantry on a new site at Lahore.

The work has been in hand for the past two years and was completed in 1923 at a cost of Rs. 9·34 lacs (£62,000 approx.). The project included the provision of quarters for two married and three single officers, officers' mess, barracks, dining-halls, quarters for married British other ranks, institute, hospital, and all other necessary buildings, as well as electric lights and fans.

The provision of accommodation at Quetta for a battery of R.F.A. was also completed in 1923 at a cost of Rs. 9·35 lacs (£62,000 approx.).

This accommodation was necessary owing to the sale of a portion of the Cantonment at Karachi, including the R.F.A. barracks, to the Civil Authorities, and also included quarters for officers, etc., as at Lahore, with the addition of stables, gun-shed, and a veterinary hospital.

The following projects also were in progress or sanctioned during the year under review :—

| Accommodation for :— | Rs. |
|---|---|
| (i) A medium Artillery (tractor-drawn) Battery at Ferozepore ... ... ... ... ... | 4·69 lacs |
| (ii) An Armoured Car Company at Kirkee ... ... | 1·02 ,, |
| (iii) Mechanical Transport personnel attached to a Medium Artillery (tractor-drawn) Battery at Delhi ... ... ... ... ... | 0·41 ,, |

Apart from the above large projects, a great deal has been done to bring existing accommodation up to date, adding married quarters, improving institutes, and making up deficiencies generally.

### I.—ACCOMMODATION FOR INDIAN TROOPS.

In former years the provision of accommodation for Indian Troops was financed from what was known as the " Hutting Grant Fund " and the work was, in the great majority of cases, carried out by the troops themselves, without expert workmen or technically qualified supervisors, and the result, in most cases, was deplorable.

In 1910 it was decided by the Government of India that all future projects in connection with the construction or reconstruction of

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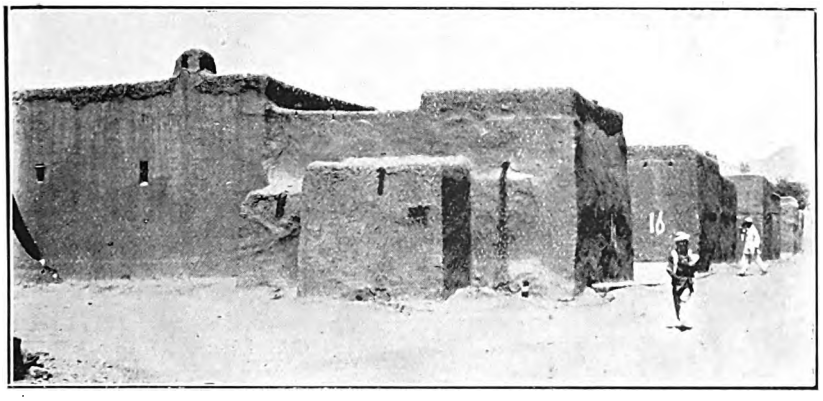
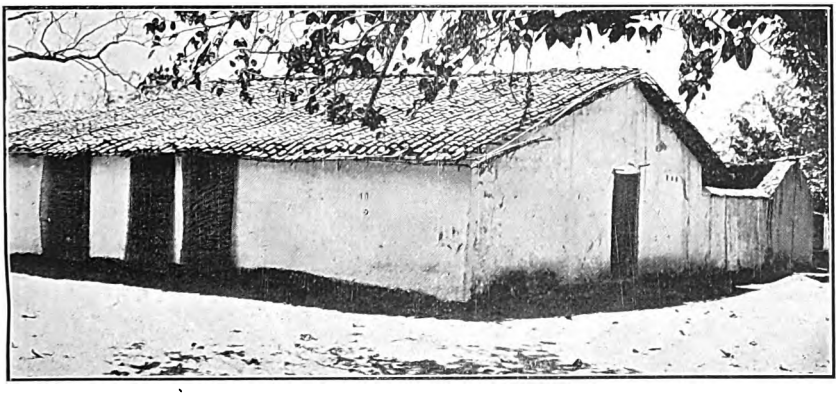
# ACCOMMODATION FOR INDIAN TROOPS.

## OLD AND NEW TYPES.



Indian Officers' Quarters. Old McQueen Lines, Kohat.



Indian Officers' Quarters. Old Mervara (I.I.) Lines, Ajmer.

Married Men's Quarters. Old Carnegy (I.I.) Lines, Bombay.

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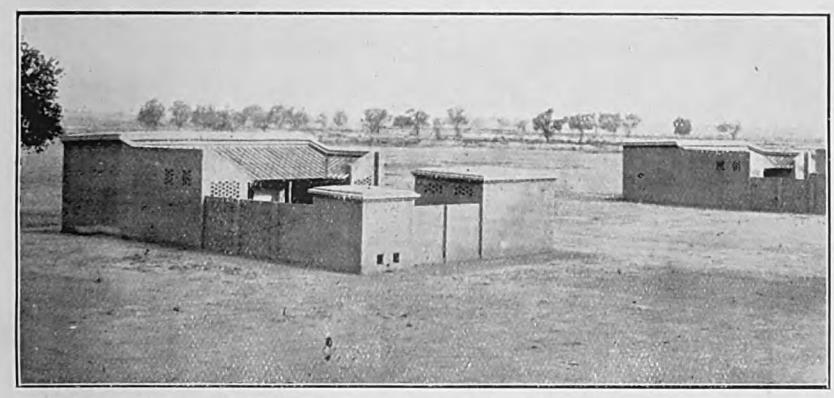
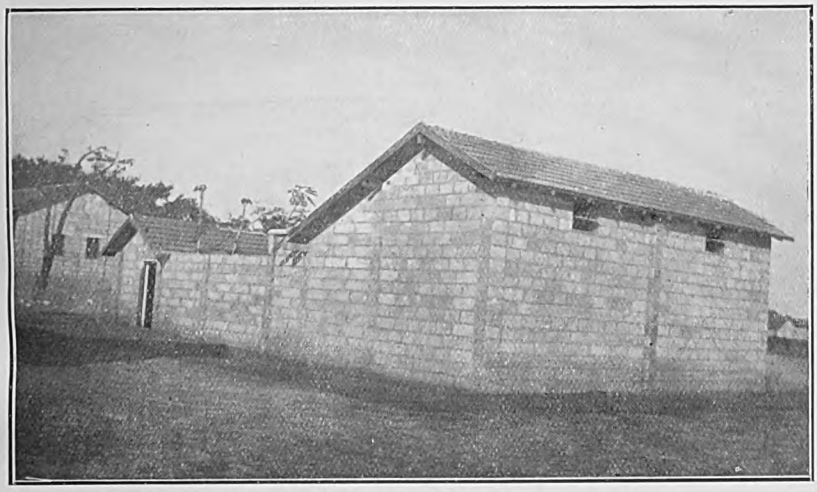
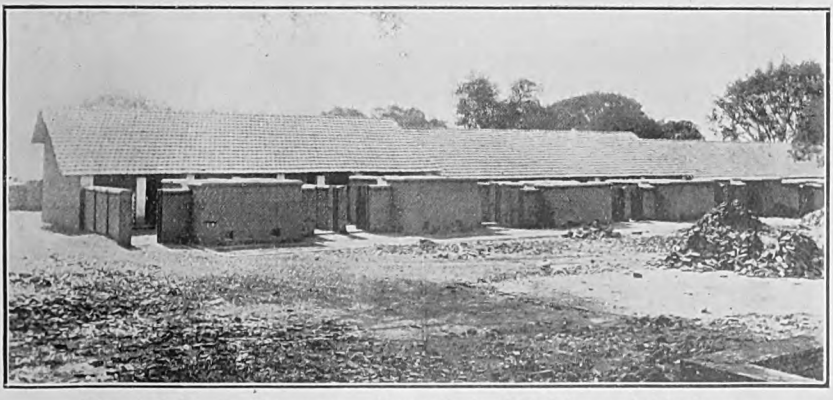


Indian Officers' Quarters. New Ferozeshah (I.I.) Lines, Ferozepore.



Indian Officers' Quarters. New Westmacott (I.I.) Lines, Kirkee.



Married Men's Quarters. New Shah (I.I.) Lines, Jubbulpore.

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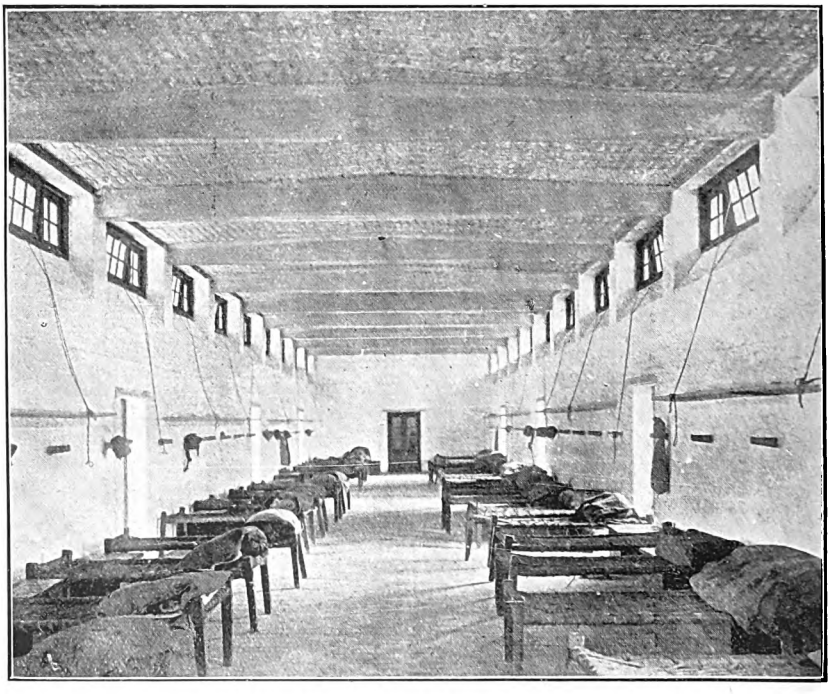
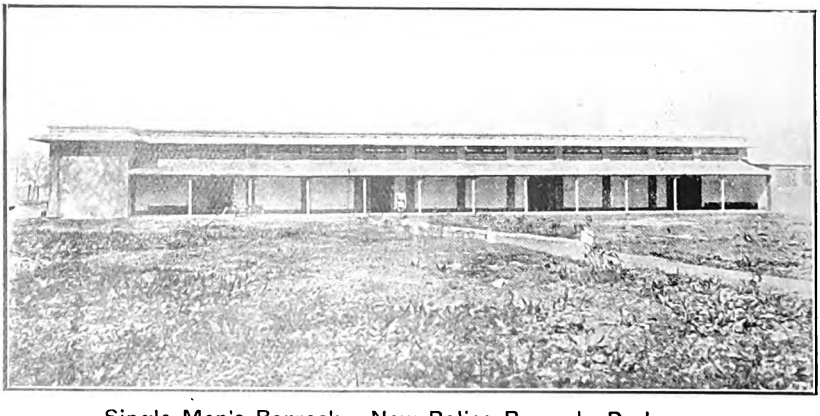


Single Men's Barrack. Interior View. New Police Barrack, Peshawar



Single Men's Barrack. New Police Barrack, Peshawar.

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Indian Troops' lines should be carried out by the Military Works Services, now known as the Military Engineer Services.

During the past year work has been in progress or initiated on the construction or reconstruction of about 40 sets of lines for Indian Troops.

The average cost of a complete set of Indian Troops lines, excluding quarters for British officers, is about Rs. 6·00 lacs (£40,000 approx.).

Comparative photos are attached showing the old and new type of lines.

## J.—Ordnance Factories.

Apart from the large number of comparatively small works in hand at the various Ordnance Factories in India, *e.g.*, new quarters for officers and subordinates, extensions to existing workshops, tramways, etc., the closing down of the ammunition factory at Dum Dum and the extension of the ammunition factory at Kirkee have been sanctioned, involving an expenditure of about Rs. 20 lacs (£126,000 approx.) in providing new buildings and machinery. Of this project the M.E. Services will be responsible for the expenditure of about Rs. 11·5 lacs.

## K.—Hospitals.

A considerable amount of work has been done in improving and adding to existing hospitals to bring them up to date, both in accommodation and internal fittings and furniture. Among the major hospital projects in progress or initiated during the year the following may be mentioned :—

(i) *Bannu.*—New Indian station hospital of 120 beds, with administrative block, dining-halls, operating theatre and X-ray room, laundry, mortuary, infectious and isolation wards, quarters for nursing sisters and subordinates, ambulance shed, etc. Cost, Rs. 10·17 lacs.

(ii) *Murree.*—New British family hospital of 40 beds. Cost, Rs. 1·67 lacs.

## L.—Medical Store Depôts.

(*a*) The Medical Store Depôt at Bombay, cost Rs. 14·09 lacs, is approaching completion. This Depôt consists of three double-storied blocks, each 150 ft. by 40 ft., and one three-storied block 320 ft. by 63 ft., all for manufacture of drugs and medical appliances ; also an office block ; all complete with shelving, machinery, electric lights and fans, etc. ; and water supply for manufacture and fire services.

The floors of the three-storied block are of reinforced concrete on the " mushroom " system of reinforcement, on internal reinforced

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concrete columns spaced 20 ft. centre to centre each way ; and each floor is calculated to take a super load of 2 cwt. per sq. ft.

(*b*) The Medical Store Depôt at Madras, cost Rs. 4·69 lacs, is also approaching completion. For this Depôt the existing buildings of the old Gun-Carriage Factory were utilized to a large extent.

### M.—Sanitation and Drainage.

(*a*) The Government of India sanctioned, in 1922, at a cost of Rs. 3·80 lacs (£25,300 approx.), the improvement of the storm water drainage of Lahore. The cost of the M.E. Services' portion of the work amounted to Rs. 3·40 lacs, the balance being apportioned between the Lahore Municipality and the Punjab Drainage Board for work to be done in their respective areas of control.

This project was initiated in consequence of an outbreak of cholera in Lahore Cantonment, and consists mainly in the lining existing open drains to prevent stagnation, the widening of culverts and the reconstruction of a railway bridge.

The project is now nearing completion.

(*b*) In 1922 the Government of India sanctioned, at a cost of Rs. 100,810 (£6,700 approx.), the improvement of the drainage on the Ridge, Jubbulpore. This was in consequence of the very high incidence of malaria among the British troops on the Ridge, which at one time was so bad that the barracks had to be vacated.

The project consisted of lining existing open drains to prevent stagnation and breeding-places for mosquitoes, and clearing away dense jungle undergrowth.

The project is now practically completed, enabling the barracks to be re-occupied, and has brought down the percentage of malaria to a negligible amount.

### N.—Accommodation for Mechanical Transport.

(*a*) Since 1918 work has been going on to provide workshops, stores, reserve parks for motor vehicles, living accommodation, etc., etc., for M.T. units at Chaklala, about five miles from Rawalpindi. The Government of India has, up to date, sanctioned the expenditure of about Rs. 80 lacs (£530,000 approx.) for this purpose, of which about Rs. 69 lacs has already been spent.

(*b*) Among recent sanctions accorded by Government for the provision of accommodation for M.T. units are the following :—

| | Rs. |
|---|---|
| *Bannu.*—Accommodation for the Headquarters and two sections of a Light Indian M.T. Company (30 cwt. lorries) ... ... ... ... ... (About 80% completed.) | 2·05 lacs |
| *Sitapur.*—M.T. Training School ... ... ... (About 90% completed.) | 1·09 ,, |

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| | Rs. |
|---|---|
| *Calcutta.*—M.T. Company, utilizing existing available buildings ... ... ... ... ... ... (About 80 % completed.) | 0·40 lacs |
| *Karachi.*—M.T. Company ... ... ... ... (Work not yet commenced.) | 1·22 ,, |

(*c*) Estimates are at present under consideration for the provision of accommodation for M.T. at Poona, Bombay, Quetta, and for certain additional accommodation at Bannu.

### O.—Remount Department Works.

Projects are in hand, or about to be initiated, for the provision of accommodation for the Remount Department at Multan, Montgomery, Saharanpur, Sargodha, Mona, and Hapur, at a cost of about Rs. 3·95 lacs.

### P.—Farms Department Works.

Various quarters and offices for the Farms Department are in progress at Sialkot, Lahore, Jubbulpore, Kirkee, Quetta, and Dehra Dun, at a cost of Rs. 1·00 lac approx., and estimates are under consideration for railway sidings for the above Department at Quetta and Hafizabad (about 40 miles from Wazirabad).

### Q.—New Cantonments.

(*a*) *Delhi.*—For a complete Brigade, in modern up-to-date buildings, including officers' quarters and messes, hospital, etc. Total cost about Rs. 120 lacs. The major portion of the work has been completed by the Public Works Department. The M.E. Services have now taken over the project for completion.

(*b*) *Razmak.*—For two Brigades, in semi-permanent huts and providing only for essential requirements. Total cost, Rs. 62 lacs approx. Work about to be commenced.

(*c*) *Khormaksar* (*Aden*).—For the major portion of the Aden garrison, owing to the modern unsuitability of the accommodation in Aden. Cost not yet known and consequently the project has not yet been sanctioned.

### R.—Marine Works.

Quarters for the Deputy Director, Royal Indian Marine, Bombay. Cost, Rs. 1 lac approx. Recently completed.

New three-storied block of Stores, Bombay. Cost, Rs. 2·28 lacs. Approaching completion.

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S.—MISCELLANEOUS WORKS. Rs.

(*a*) *Maymyo.*—Offices for Headquarters, Burma District ... ... ... ... ... ... 1·11 lacs
(Approaching completion.)

(*b*) Removal of a complete set of Indian Infantry Lines and officers' quarters from Bhamo to Maymyo. These were dismantled at Bhamo and transported by steamer down the Irrawady to Mandalay and carried by rail to Maymyo. The whole work was done by the 3/2 Bombay Pioneers and Burmah Sappers and Miners. The buildings are two-storied and built of teak with shingle or tile roofs ... 1·25 ,,

(*c*) *Lahore.*—O'Dwyer Memorial Institute for British and Indian soldiers ... ... ... ... 1·18 ,,
(About 80% completed.)

(*d*) *Lucknow.*—Additional cells for the Detention Barracks ... ... ... ... ... 0·29 ,,
(Just starting.)

From the above it will be seen how many and varied are the works on which the Engineer officer in India may be employed in the Buildings and Roads Branch of the Military Engineer Services, and the numerous problems, both of design and execution, that may confront him during his service in India.

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## SURVEY OF INDIA.

### REPORT FOR 1922–23.

OWING to financial retrenchment the field operations of the parties employed on geodetic work were considerably curtailed, and the Astronomical, Pendulum, Triangulation and Base Line Parties did not take the field at all.

The Tidal Party carried out tidal registrations at nine tidal observatories, and a new tide gauge, which is expected to be in working order before the end of 1923, will shortly be installed at Bassein. Data for the prediction of tides for 1924 were computed for 40 ports and the detailed compilation of tide tables for nine riverain ports was completed.

The tide-predicting machine which was received from the National Physical Laboratory, Teddington, in 1921, has been erected at Dehra Dun; it was used for the first time in 1922, and the tide-tables for 1924 were completed and issued by October, 1923. Before the installation of this machine, data for tide predictions had to be

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sent to England every year, but in future this will no longer be necessary.

The increasing demands for accurate bench marks for irrigation projects have made heavy calls on the Levelling party, this party, working in five double and one special detachments, completed 205 miles of primary, 2,793 miles of secondary, and 13,889 miles of tertiary levelling, chiefly in connection with the Sukkur Barrage and Ghatprabha projects in Bombay, the Sutlej Valley Project in the Punjab and various projects in Burma.

The Magnetic Party recorded daily absolute magnetic observations for declination, horizontal force and vertical force at the Dehra Dun and Toungoo observatories, and observations for the comparison of instruments were made at these two observatories as well as at the Kodaikanal and Alibag observatories, which are controlled by the Meteorological Department. Magnetic observations were taken at six repeat stations to supplement the five-yearly observations made at all repeat stations, and to ensure the accurate determination of the annual changes in the magnetic elements.

Topographical surveys, which constitute the main work of the department, were carried out by 13 parties and the total output of 61,648 square miles constitutes a record for the area surveyed in any one year. Triangulation or traverse was also carried out to supply points for the surveys of 1924. Survey was mostly on the 1-in. and $\frac{1}{2}$-in. scales, but the $\frac{1}{4}$-in. scale was employed for some 3,000 square miles in Rajputana, and many scattered forest areas were surveyed on the 2-in. scale. The publication of new topographical maps, which mostly represent the surveys of the previous year, amounted to 97 1-in. sheets, 74 $\frac{1}{2}$-in. sheets and 63 $\frac{1}{4}$-in. sheets.

The scattered nature of the topographical operations is exemplified by the distribution of the parties, which was as follows:—

> Three parties worked in Burma, 2 in the United Provinces, 1 in the United Provinces and in Bihar, 1 in Bengal and Bihar, 1 in the Punjab, 1 in Central India, 1 in Hyderabad State, 1 in Madras, 1 in Bombay and 1 in Assam, and altogether work was carried out in 52 districts and in 49 Indian states.

To meet the increasing demands of local Governments for special surveys outside the normal topographical programme of the department, two parties are now employed on special work in the Punjab; one of these is employed in fixing permanent traverse points for the identification of boundaries in the extensive riverain areas of the Punjab, and the other is employed in laying down by traverse permanent marks representing the corners of rectangles which will be utilized by Settlement and Irrigation Officers as the basis of their surveys.

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It is probable that in 1924 two more parties may be somewhat similarly employed in various parts of the country.

The three parties working in Burma have, in the past, been administered by the Superintendent, Eastern Circle, from Shillong, but they are now grouped into a new Burma Circle under the Superintendent, Burma Circle, with headquarters at Maymyo.

The Cantonment Party carried out large-scale cantonment and bazaar surveys in Bareilly, Agra, Muttra, Sitapur, Gorakhpur and Naini Tal.

A new party is under formation to deal with air-photo surveys and will be employed next year in connection with air-photo surveys of the Irrawady Delta.

A special survey party has been formed and placed on " foreign service " at the disposal of the Bhopal State to carry out traverse work in that state.

Two survey detachments were formed during the year and were employed on field service as the Razmak and Waziristan detachments; the latter of these is still at work.

A detachment was employed on survey work in Persia for the Anglo-Persian Oil Company; this detachment will be again employed in 1924.

The six drawing offices and publication offices at Calcutta and Dehra Dun have been fully employed in drawing geographical and general maps, small-scale topographical maps and special maps; over $1\frac{1}{4}$ million sheets, of a face value of over $6\frac{1}{2}$ lacs of rupees, were printed during the year, and the Map Record and Issue Office, Calcutta, issued over $1\frac{1}{6}$ million prints, of a total value of over $4\frac{1}{2}$ lacs.

The Mathematical Instrument Office at Calcutta, which supplies and repairs instruments for all Government Departments in India, did work valued at over $4\frac{3}{4}$ lacs in its workshops, and issued instruments to Government Departments of a total value of over $6\frac{1}{4}$ lacs.

During the year the death occurred of a very senior officer of the Department in Colonel Godwin Austin, who retired in 1877; the name of Godwin Austin has long been associated with the nameless peak in the Karakoram Range, which was first observed by Captain T. G. Montgomerie, R.E., when he was employed on the triangulation of the Great Trigonometrical Survey, and was then given the serial identification number of K2; subsequent computation fixed the height of this peak as 28,250 ft. and thus determined it to be the second highest known peak in the world. The name Godwin Austin seems to have been first suggested and accepted for this peak at a meeting of the Royal Geographical Society in 1888, in consideration of the fact that the first topographical survey of the southern portion of the Karakoram Range was carried out by Godwin Austin.

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Major-General D. A. Scott, C.B., C.V.O., D.S.O.,
Colonel-Commandant R.E.

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# *MEMOIR.*

## *MAJOR-GENERAL DOUGLAS ALEXANDER SCOTT, C.B., C.V.O., D.S.O., COLONEL-COMMANDANT R.E.*

"WE regret to announce that Major-General Douglas Alexander Scott, C.B., C.V.O., D.S.O., late R.E., died on 5th February, after an operation in a nursing home at Oxford, in his 76th year.

"The death of General Scott deprives the commissioned ranks of the old Army of one of their most distinguished representatives, and one, moreover, who can hardly be said to have received reward commensurate with his services. Born on December 14th, 1848, the son of John Scott, M.D., he was gazetted to a lieutenancy in the Royal Engineers from the Royal Military Academy in January, 1870. Proceeding almost immediately to India, he was employed as a consulting railway engineer, and was in charge of the Royal train on the journeys which the late King Edward made all over the peninsula when he visited that country as Prince of Wales in 1876.

"As a subaltern young Scott saw service in the Afghan War, and had not long been a captain when Arabi Pasha's rebellion induced the British Government to send an expeditionary force to Egypt in 1882; Captain Scott accompanied it and was rewarded for his services with the brevet majority. He remained on in Egypt among that band of rising young officers who had the prescience to see that there was reward to be gathered for good service, became Director of Sudan Railways during the campaign of 1884–5, and served as D.A.A. and Q.M.G., being again "mentioned" and securing a D.S.O. and a brevet lieutenant-colonelcy. He now served for some time at home, was A.A.G of Royal Engineers at Army Headquarters from June, 1894, to June, 1899; C.R.E., Southern District, from June, 1899, to September, 1902; as a major-general he was C.R.E. of the Second Army Corps from September, 1902, to September, 1905, and during the ensuing four years he commanded the Coast Defences of the Eastern Command. He was given the C.B. in 1897, the C.V.O. in 1901, and was appointed Colonel-Commandant Royal Engineers in 1921.

"In 1894 General Scott married Mary, daughter of the late Captain Cardew, 74th Highlanders, and had one son and two

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daughters. Mrs. Scott, who was a grand-daughter of Lord Chancellor Westbury, died in 1918."—(*Extract from "The Times" of Wednesday, 6th February*, 1924).

General Douglas Scott was a brother of Sir John Scott, Bart., who was instrumental in securing the Wallace Collection for the nation. Considerable details of his work in command of the 8th Railway R.E. in Egypt in 1884 will be found, given by himself, in the Memoir of Lieut.-Colonel Pelham von Donop, which was published in the *R.E. Journal* of February, 1922. In commenting upon these notes, Major-General Sir Richard Ruck, K.B.E., C.B., C.M.G., the writer of the Memoir, called attention to the fact that this was the first British campaign in which military railway companies formed an important feature in the supply of an army in the field. A correspondent states that General Douglas Scott claimed to have been the first officer to *receive* the D.S.O., and that he was very proud that an officer of the Royal Engineers should have been the first recipient of the Order.—(EDITOR, *R.E.J.*)

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# *BOOKS.*

## LIFE AND ADVENTURE IN PEACE AND WAR.

By Major-General Sir ELLIOTT WOOD, K.C.B., D.L. Edward Arnold. Price 16s.

IT is sometimes advanced, as one of the advantages of a commission in the Royal Engineers, that the exceptional facilities for extra-regimental employment, in such services as Colonial Administration, Indian Survey or Public Works, or the like, give opportunities such as are not normally enjoyed in other branches of the Army for adventurous experiences, as well as for a wider sphere of useful work, in various parts of the British Empire. Whatever truth there may be, and doubtless is, in such a claim, it was certainly not due to any such collateral circumstances that Sir Elliott Wood was able to enjoy, and now to record for the benefit of others, a very remarkable life of adventure and useful service. He was during the whole of his service, practically, a regimental officer, for, although at one period he was an A.D.C., it was on the staff of the I.G.F. (Sir Lintorn Simmons), and though he was later on the H.Q. staff at the War Office, it was as A.A.G. of his Corps, and therefore during both those staff appointments, he was in close and constant touch with the regimental administration of the R.E. Nor can it be said that, in this long life of close association with the regimental work of the Corps, he was not also associated with its great task of construction, for he had the duty, in many places and under varied conditions, of designing and executing many important works. The supervision of the building of Knightsbridge Barracks in London, for instance, came under his charge when he was still a subaltern. The development of the fortress of Malta, from the medieval condition in which it was after the Crimean War to its present spacious and complete modern state, was largely due to his plans and superintendence, and especially this is the case in the utilization of the natural features of the island along the Victoria Lines which he planned and executed. These are some of the works which he carried out, wholly or in part, and it may be said that throughout his career he filled the not-too-easy *rôle* of soldier and engineer, thoroughly efficient in both.

His book, therefore, is an account of how, in the usual routine of an engineer officer's regimental life, opportunities can be used. He did not seek personal advantage, nor go out of his way to ask for comfortable billets. He took the rough with the smooth, and, like the good sportsman he is, rode straight, with his heart in the right place. The result is a really amazing record of good work done, and adventures of no ordinary character.

He takes us into his confidence, very pleasantly though briefly, in his account of his family life. Fortunate in having a home in a lovely part

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of England to which at all times his thoughts would turn, and to which he has now retired "with years and honours crowned," still more fortunate in having in his home life parents of the godly, upright character that is of such unspeakable blessing to their offspring, he had the very best of preparation for a career of usefulness and legitimate enjoyment of life. Incidentally, it is possible to notice and admire the solidarity of the family ties, and to realize what must have been the lofty example of the parents who so united their sons in mutual esteem. One likes to think that such instances of personal family unity, in our country, are not rare, and that the influence of such homes is a strong national asset.

One of the results of early influence was the love and attraction which Sir Elliott has had for animals. His dogs are a delightful feature of his reminiscences, and their companionship must have been most real to him. There is a charming little account of how he swam the Mahmoudiyeh Canal in the first Egyptian War with a derelict kitten perched on his neck and purring with its paws on his head. And the adventures which he shared with his horses, and especially with his charger and hunter "Merriman," would themselves fill a volume, are they not written in the Chronicles of the Chase at Aldershot and the Curragh?

Then he had the advantage of being associated, if not intimate friends, with some very notable men. He was A.D.C. to Sir Lintorn Simmons, as above noted, and with this chief he went to the Berlin Conference in 1878, when he came in touch with many notable people—the Emperor William, the Crown Prince (afterwards Emperor Frederick), Bismarck, and many others. With Sir Lintorn also was associated Sir John Ardagh, and (earlier) Sir Charles Watson, both men who made their mark in the Army, and the Corps, and close personal friends of Sir Elliott Wood. An even more remarkable man than any of these was General Charles Gordon, with whom Sir Elliott was associated on many occasions, and it is especially interesting to learn that he and another officer (Captain Kelham, H.L.I.) were actually under orders to accompany Colonel Stewart to Khartoum and join Gordon there, and that on the very day that they were to start from Cairo those orders were cancelled. One cannot but wonder what would have been the result had another R.E. officer, of Sir Elliott Wood's calibre, been with Gordon at Khartoum. One is at least justified in assuming that in that case Khartoum might have held out for a few days longer and "in any case I should have been some comfort to my old friend, the lonely hero." History might have been very different if those orders had not been cancelled till a few hours later.

The whole story of the Nile Campaign is one of sad regrets for what might have been, and of discredit to the politicians of our country.

Sir Elliott was associated in Egypt with many men who played a most conspicuous part in the early days of our occupation, both in civil and military life, and of our campaigns in that country and the Red Sea littoral. It is a period in our military history of the deepest interest to the Corps, for both in military developments and in engineering R.E. officers were ever conspicuous. In the operations in and near Suakin none did better work than Sir Elliott Wood and his admirable Company,

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the 17th. This Company, under the same officers, had done good work in the 1882 campaign, both at Alexandria and on the main line of attack, but it was on the Red Sea littoral in '84 and '85 that it did specially invaluable service, and it was there that its gallant commander's adventures were so thrilling. Sir Elliott was not only, in one capacity or another, in all the fights that took place—battles where there was comparatively little of modern military science, but a great deal of primitive hand-to-hand fighting—but he was in the thick of them, "a bonny fighter" of the good old-fashioned sort. The following is a sample worth quoting (though not more so than many others):—

"I was retreating with the men, firing my revolver at close quarters over my horse's back, and so not looking where we were going, when the horse came to a standstill. Looking round I saw we were blocked by a mimosa bush, round the sides of which the men were pressing to whose difficulty it was impossible to add. My revolver was empty, so I thought 'That's the end of E.W.' Then I remembered I was on a big English hunter, who had no deterrent experience of the mimosa thorn, so roused him up vigorously and he got over and through it. We jostled a man on the other side, to whom I apologized and hoped he was not hurt. A poor fellow badly speared said 'Don't leave me,' so he was told to hang on to my boot, but after a few steps he said 'Oh, I can't,' so I leant down low and somehow or other—one hardly knows how—managed to lift him up, and bear him a short distance, etc."

One might quote page after page of this personal experience; it is told in the simplest fashion, but is all the more convincing as to the cool head and active brain that was ever on the alert for useful co-operation with others. His experiences at Suakin were not only those of desultory and intensive fighting, but also those that fall to the R.E. under any circumstances, such as building huts and hospitals, arranging for water supply and landing stages, roads, etc., and he notes, what many of us have often found, that "the worse the climatic conditions, the more important it is to have plenty of interesting work to do, instead of lying in tents." There was sport also to be had, however; bustard and sand grouse, and occasionally larger game, such as gazelles, fell to his gun.

The activities of the enemy began to mount again as the weather got cooler in 1884, and the season's campaign of 1884-85 was quite as full of incident as that of the previous year. The enemy were adepts at night attacks, and they seemed to have an extraordinary faculty for discovering land mines laid out for their benefit. The R.E. officer (Lieut. Askwith), who was placed under Sir Elliott for the purpose of working the mines, was himself blown up, and his detailed report of actual positions, which he had intended to submit, was destroyed with him; so it fell to Sir Elliott's lot to find out where the mines were and remove them, a duty which he performed himself alone, and a very hazardous task it was. This was prior to the action known as "McNeill's zereba," in which he was, as usual, in the thick of the fighting.

The 17th Company was commanded by him in peace and war for nine years, during which time he had risen from being a junior captain to a brevet-colonel. It is no disparagement to the other admirable services rendered by Sir Elliott Wood when it is stated that possibly

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the greatest service he rendered to the Corps of R.E. and the Army was the extraordinary efficiency of that Company, as it was when he brought it in the last year of his service with him from Aldershot to the Curragh. Up to that time field companies were not very favourably regarded by anybody. Senior officers of R.E. were inclined to regard them as not sufficiently good engineers, other branches of the service were doubtful of their value as soldiers. The 17th Company, under Sir Elliott Wood, was a model for any troops; officers, and N.C.O.s knew their work, each had his own allotted sphere of duty, and collectively they worked together admirably. The Commander of the Forces in Ireland, a Guardsman, said the field companies were the smartest and best troops under his command (which included many *corps d'élite*). Sir Elliott himself, owing to his high army rank, often commanded composite bodies on manœuvres, and it was freely said that his presence was equal to a battalion. At ceremonial reviews—more common then than now—where he commanded, everything went with smooth regularity. The prestige of the Corps was very high. (These facts are not, of course, mentioned in the book, but they are known to all R.E. officers who served in Ireland at that time.) As engineers, too, the 17th Company did admirable work, everywhere useful and in some cases solving difficult engineering problems—such as the Hare Park Well at the Curragh—in record time.

Sir Elliott's service in the South African War, where he was Engineer-in-Chief, was naturally on a different and higher level than the exciting experiences he had in the Sudan. He was at first sent to De Aar to command the Frontier Posts, as well as carrying on his duties as Engineer-in-Chief—a combination which seems strangely at variance with modern practice. This command he retained until the arrival of Lord Roberts as Commander-in-Chief in February, 1900, when he reverted to his original duty as Engineer-in-Chief, after several months of very responsible and difficult command.

The nature of the warfare in South Africa did not lend itself, as in the Great War, to the direct supervision and control of the Engineer-in-Chief. Sir Elliott was with Lord Roberts in the Paardeberg operations, where his advice was valuable and bore good fruit, and this was also the case in the subsequent advance to, and occupation of, Pretoria. In the later parts of the campaign he had much to say to the initiation and extension of the blockhouse system (there were 8,000 blockhouses constructed) and in many problems of water supply, railways and other communications. He found the difficulty of engineer stores and supply a serious one, as we all do in war, and also the not uncommon obsession in the minds of transport and supply officers that such stores are of secondary importance, irrespective of the nature of the military operations which may be absolutely dependent on them. He was less fortunate also in two respects than we were in the Great War, in that the Commander-in-Chief (unlike Lord Haig) did not appreciate and praise work done, and the Contract Branch at the War Office could not cast off (as it did of late) the costly and dilatory routine methods of peace. It is, however, possible that the troubles which Sir Elliott experienced made the way open for future and more reasonable procedure.

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So much for the military adventures recorded in this book. We have, however, still to comment on the very remarkable experiences of Sir Elliott Wood as a builder and navigator of canoes. To one who is not in any way an expert in amphibious matters, the account of these voyages, and the skill with which the fragile craft was saved from destruction and the navigator from a violent end, reads nothing short of miraculous. It must surely mean more than ordinary nerve to discuss the possibilities of attempting a voyage in a small canoe round the stormy coast of South Africa, and actually to circumnavigate the group of islands at Malta, besides inland voyages down the Danube, Rhine, and many streams in the British Islands.

Where Sir Elliott first learnt to navigate boats is not told, but he evidently joined the Corps at Chatham with a good working knowledge of sailing and rowing, and seems to have been as much at home in the water as any aquatic animal. It was not until he was, as a subaltern, at Cape Town that he built, to his own design and with his own hands, the first of his three *Zephyrs*, canoes 13½ feet long and 2 feet 4 inches beam, weighing 66 lbs. "The whole frame is so elastic that in 35 years of canoeing, including the descent of many a rocky rapid, the framework of a *Zephyr* has never once been damaged by bumps or collisions." A pretty severe test of naval construction. So much for the canoe. A picture of this craft with its designer is given, and affords to the uninitiated a better idea of the hull, masts and sails than any lengthy specification.

Of the voyages, and hairbreadth escapes, that he had in these successive *Zephyrs*, it is only possible to give the very barest outline.

The first *Zephyr* was launched in stormy seas at Cape Town. In her the intrepid owner made some four long canoe trips, navigating rivers never before explored, and undergoing risks which all expert opinion regarded as foolhardy. The appetite for further adventure was stimulated on his return to Europe, and he navigated the Thames from Hammersmith to Shoeburyness, and across the Nore, returning by the Medway. Then followed service at Malta, where the Mediterranean is by no means always like a mill-pond, but where the *Zephyr* made light of the rough weather. In later years, with one of his brothers, in a second *Zephyr*, Sir Elliott had two varied trips in Scottish waters, with a good many hairbreadth escapes. A few years later, with the same brother, a most unique voyage was taken round Malta and Gozo, not entirely for pleasure, as the reconnaissance of possible landing places was an important object for the trip, which certainly was not one usually undertaken by two senior field officers!

In 1896, having built a third canoe of the same pattern, three brothers (whose united ages were 150 years) navigated the Danube from the Black Forest for 780 miles to Buda Pesth—a most interesting voyage, full of adventure.

In later years, after his retirement from the Army, when he was well past the usual age for such enterprises, he navigated the Rhine from Switzerland (the Reuss) to Cologne.

This takes no account of trips in England, among rivers and estuaries in the West country especially.

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Even this brief outline, however, is sufficient to indicate how Sir Elliott Wood seems endowed with perpetual youth, if not in years, at least in activity and spirit. He comes of a long-lived race and, like his canoe, is possessed of a buoyancy which has borne him cheerfully in life's voyages, always making the best of the weather and steering straight for difficulties with a clear head ready for instant action.

His many friends, both in the Corps and in the wider circle beyond, congratulate him on this record of his adventures, and hope that he may long live to enjoy the retrospect.

G.K.S.-M.

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## GEOHYPSOGRAPHICAL PROBLEMS.

The problems in question are those which deal with the heights of the land surface, the depths of the sea, the areas of sea and land, their mean heights, their volumes, densities, and so on. The *Revue du Génie Militaire* has recently published some articles on the subject by Colonel A. Romieux, and these have been issued in book form.* The author has been studying the question for many years; indeed, his first paper was presented to the Academy of Sciences as far back as 1890. In 1895 H. Wagner wrote a critical study of the state of our knowledge of these matters up to that date, and included a discussion of Colonel Romieux's hypotheses; he published a second study, with amended figures, in his *Lehrbuch der Geographie*, in 1912. Amongst other writers who have contributed estimates of areas and volumes may be mentioned Lapparent, Penck, Supan, Heiderich and Murray; so that anyone who wishes to go more deeply into its history has a considerable literature at his disposal.

The interest of Colonel Romieux's work is chiefly that he finds certain relations to exist between the levels and the densities of the land and the sea masses. He first takes a "surface of equideformation," that is the surface of revolution which would exist if there were no sea water and if the land masses were levelled off to fill up the sea basins, leaving a uniform, smooth earth. He then finds that there is:—

(1) An equality of *level* between the sea water uniformly spread over the whole earth and the land *remblai* covering the terrestial areas.

(2) An equality between the weight of this *remblai* (or the equal, corresponding *déblai*) and the weight of the waters of the sea.

The author devotes a great part of the book to the exposition of a theory, which is to explain the reason for these two equations, by means of the play of an oceano-continental equilibrium in cycles of successive deformation. These ideas should be taken in conjunction with those of isostasy, with the conceptions of "sal" and "sima," and perhaps with the (at present quite unproved) theory of Wegener of floating continents. We do not, as a fact, yet know very much of the mechanism at work with regard to the equilibrium of the earth's crust. But studies like those of Colonel Romieux, by presenting special points of view, will assist us to arrive at correct conclusions.

* *Recherche Géhypsographique.* Colonel A. Romieux. Imprimerie Berger-Levrault. Paris, 1922.

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The reviewer may, perhaps, be permitted to grumble at the plates which accompany the volume. The first plate, which shows the "geohypsographical curve," gives no indication of the ordinates used, and, to find these, it has been necessary to consult Wagner's article of 1895. The other figures are crowded together, away from the text which refers to them, and this greatly increases the labour of reading the book.

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## EMERGENCY WATER SUPPLIES.

By A. Beeby Thompson. Crosby, Lockwood & Son, London. Price 21s.

The true inwardness of this book, which is dedicated to the Engineer-in-Chief and the R.E. officers of the Salonika Army, is not revealed by the simple title upon the cover, and it is not until the title page is investigated that one begins to realize the importance of the book for military engineers.

Mr. Beeby Thompson may be said to have been the *deus ex machina* who solved the water problem for the Allied Armies in Macedonia. Yet his experience was not confined, during the war, to that inhospitable area. He also worked in Egypt and Gallipoli and his achievements in the latter theatre were conspicuous. To a ripe, scientific and commercial experience he brought a fertility of resource and an energy of execution for which the hospital patients and refugees at Salonika, quite apart from the inhabitants of the divisional areas in "the line," have every reason to be thankful.

Mr. Thompson pays some pretty compliments to the Corps of Royal Engineers and the Army in his book; they are less deserved than what we ought to say of him.

To turn now to the text of the book. It deals with Hydrology generally, the Hydrography of Macedonia, Development of Water Sources, Utilization of Norton Tube Wells, Deep-well Boring, Pumping Equipment and Water Analysis.

The earlier chapters are written in a language which, I fear, will be a little obscure to the average soldier engineer, but we shall refer to this later. When we use the word "language" it should perhaps be stated that it is the terms and nomenclature that are particularly alluded to.

What seems to us to instantly emerge from a perusal of the book is the enormous importance of geological knowledge to the military engineer. This functionary in our experience is looked upon by the Army in much the same way as Moses was viewed by the Hebrew tribes. He is supposed not only to know where water is, but to lead it, so that it will drip gently out of a tap, into every thirsty mouth. In the time when the present writer sat at the feet of Schoolmen, Geology was not one of the many things his mind was required to assimilate and it was only by private pursuit that any knowledge of the sort could be acquired. This seems to be an important fact on which to lay stress, for without geological knowledge no one can emulate Moses as a water finder.

From the point of view of the military engineer, who may be called upon to produce water in a rough and barren country with but few

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appliances, the chapter on Development of Natural Sources and Springs and that on the use of Norton Tube Wells are especially interesting. The experience of the present writer in Macedonia was principally in respect of development and piping of springs. The area in which we operated was not ill-watered, in some places it was abundantly well watered, but a good deal of care was necessary in dealing with the natural sources.

In one case we had to pipe water two miles to a railhead to reinforce the supply from one of Mr. Thompson's bore wells, which was of rather a recalcitrant character. Our doctors discovered "Bacillus Coli" in the spring. There was a good deal of fuss and it was feared that if the engines did not die of cholera they would do so of thirst. However, the evil genius of the source seemed to yield to the treatment of vigorous gushing and disappeared. Some of the irreverent doubted whether the "Coli" had not been imported in a "sterilized" flask.

We had a noted mineral spring at Janes (the railhead mentioned above). This spring had been condemned by the *cognoscenti* as unfit for human consumption. After vigorous cleaning and protection it was, however, continually used by the 12th Corps Camp. The water was slightly aerated and made an engaging beverage when diluted with whisky: its slight aperient qualities also doubtless accounted for the general good health of camp population.

To turn now to the tube wells. Many R.E. officers doubtless have lurid recollections of the waywardness and apparent inefficiency of these instruments. In Macedonia they were an unqualified success, if they were *put in the right places* and used intelligently. Their usefulness and importance as a military store were completely vindicated.

It has been indicated above that the troops "in the line" in Macedonia lived in a fairly well watered country. It must be clearly understood, however, that the "line" was so thin that there was seldom a very large number of troops to be dealt with in any one place and the problem of water provision was therefore not a very difficult one to solve. At the Salonika base, however, matters were quite different. Here there was a vast accumulation of troops and animals, hospitals and refugee camps for which the town supplies, from Kotos Mountain and Eurenzik *via* the Roman aqueducts, was quite insufficient. Water for this great increase in the population had to be found and produced and that quickly, and it was here that Mr. Beeby Thompson's work was so invaluable. His work, however, was not confined to the base area, as, whenever and wherever his advice or assistance was required, it was instantly available.

It only remains to say that this record of achievement under most adverse circumstances should be carefully studied by all R.E. officers and that all R.E. officers should be made to study geology in its water supply aspect. This study is essential in order that R.E. officers may be able not only to study and understand contemporary scientific literature on the subject (it is for this reason that allusion was made above to the language and terms used in the volume under review) but also in order that they may be able to approach water supply problems, both in peace and in war, without an entirely "open" mind. G.W.

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## MILITARY ENGINEERING, VOLUME V (ROADS).

H.M.S.O. Price 2s.

THE inclusion of the special section on Roads as Volume 5 of the Military Engineering Series issued by the Army Council is very welcome. This volume replaces a manual on Road construction, etc., written by an officer of the R.E., and published in 1908 by the Institution of Royal Engineers for the use of Engineer officers.

The general composition of the original compilation has been followed. The subject matter has been rewritten by competent Engineer officers who took part in the Great War, giving the result of experience gained in the various theatres of action, where roads and communications played such an important part.

The present volume worthily fulfils its aim and object as a hand-book for Military Engineers and Pioneers in all parts of the world, and will undoubtedly find a place in the library of many Civil engineers and Prospectors in new countries whose prosperity can only advance by opening up roads and communications suitably aligned and scientifically constructed to meet the ever-increasing demands of vehicular transport.

It is an axiom that Roads and Communications are the avenues along which civilization is introduced into every land. No campaign in history has been carried through without " Communications " of some kind—chiefly roads and railways. Many roads in Britain and in Europe owe their inception to an invading force., *e.g.*, the Roman Roads of Gaul, Britain, Macedonia and Asia in ancient times, and Wade's roads in Scotland in the eighteenth century. Without doubt History will record a like indebtedness to Allenby's conquest of Palestine, and the occupation of Macedonia and Iraq by the British and Allied troops.

The strategic value of good roads behind a battle front is immense, the tactical value in forward areas is very great. An Army depends for its subsistence on the regular, as well as expeditious, delivery of munitions, food supplies and stores of all kinds ; so good roads are one essential to success.

The difficulty in War is to make roads which are immediately fit for heavy traffic, often within a few hours of an advance, and to maintain them for a considerable period without impeding a continuous flow of traffic. This particular difficulty was very apparent on the Western Front and in Palestine.

Where roads already exist, their surface may be good, but the foundation weak or even non-existent. To the Engineer Officer, and certainly to the inexperienced and non-technical Staff Officer, the value of an existing highway is an unknown quantity. To the experienced roadman, every road requires as critical an examination and treatment as the condition of an ordinary shoe ; like a thin sole it may last, or suddenly develop holes and require complete renewal. The lesson therefore is that " *Appearances in roads go for nothing.*"

The Engineer Officer may have to face the building of roads in a diversity of countries with great extremes of conditions. For instance, in the Near East existing roads and communications for all practical purposes in War were nil. They had for the most part to be created or adapted for military transport. Roads and Communications that

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the Mediterranean, Egyptian and Palestine Expeditionary Forces had to deal with occurred in such extremes as the sea shore and limestone strata of Gallipoli—Nile mud in the Delta of Egypt—the hard desert of Libya, the soft desert of Egypt on the west and east of the Suez Canal and the bare wastes of Sinai. Again too, in Palestine, the hills of Judea, the cotton soil of the Maritime Plain, the mountains, ravines and rocks in Samaria, and the slimy mud and almost knee-deep dust of the approaches in the Jordan valley, as well as the varied country in Mesopotamia, give ample evidence of what Engineer Officers had to contend with during the Great War.

The advent of the heavy motor transporters has rendered the problem of road construction very difficult. The problem can only be solved by a scientific examination of foundations and surfaces under moving loads, whose intensive and continuous blows and impacts demand a very high standard of resistance of materials scientifically assembled and laid. Whilst the original principles of road alignment and construction have been subject to but slight modification, their application and fulfilment by the use of new materials and methods of construction have undergone radical change. The military engineer must be prepared to regard the latter as still subject to change, as there is little doubt that the day is not far distant when roads and communications will have to be built to admit of and withstand the traffic of lorries and loads of at least fifty per cent. if not eighty per cent. higher weight than those of the present time. It is conceivable that an immense network of heavy solid reinforced concrete roads will alone suffice to meet the transport demands of the future.

Whilst Volume 5, "Roads," of itself, is very comprehensive, the Military Engineer is reminded that much information which is cognate to road construction is to be found in other volumes of the Military Engineering series—notably Volume 3, "Bridgework," where Load diagrams of the principal vehicles, guns, etc., forming part of every expeditionary force are given. Similarly, for the principles of construction of retaining walls, masonry arches, etc., attention is directed to Volume 1.

In the present volume a very useful series of Appendices is given upon materials, quarrying tools and plant which come into road-work. The illustrations and Tables have been carefully selected and compiled, and the Index is full, sensibly arranged and completely paged into essential references.

In Chapter I are enumerated the various considerations which affect the alignment of roads and communications from the standpoint of the Military Engineer, who may be called upon at any moment to reinstate and recondition communications destroyed by enemy action so as to render them fit for military transport of all kinds within a few *hours*. The necessity of careful reorganization in the field, of close and intelligent co-operation on the part of the General Staff is very rightly emphasized.

In special cases a separate Road Directorate may be needed. The absence of the above essentials reacted upon and retarded general operations on the Salonika Front in 1915–16.

Traffic control on roads under reconstruction or repair is a matter which should receive careful attention, as it is of primary importance.

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The amount of damage done by long trails of *empty* lorries bumping back daily at excessive speeds to their base, and following identical tracks, is seldom appreciated by the Q. and A. Branches of the Staff. Lorry drivers in such circumstances should be compelled to follow deviations and side routes wherever possible.

Although reference is made on page 6 to types of military vehicles it would have been helpful if something had been written about caterpillar tractors, and their nature and effect on roads.

Chapter II is devoted to Reconnaissance Survey and the factors which determine correct grading, location and alignment.

The information and principles recorded are exhaustive and excellently compiled and grouped.

Chapter III which deals with the Principles of Road Construction is perhaps the most valuable in the book. The principles given should be indelibly recorded in the memory of all Engineer Officers.

Chapter IV refers mainly to permanent macadam roads and the various expedients employed in construction, so as to maintain a hard-wearing, waterproof and dustless surface. Skilled work put in the foundation of adequate thickness and stability cannot be too strongly impressed on the Road Engineer, as the whole future efficiency of the road primarily depends thereon. The greater part of the chapter is applicable to peace conditions as apart from military conditions in the field. The ever-increasing dead weight, loads and speed of motor traffic presents a problem of great complexity—requiring careful observation and study in order to maintain any macadam road in an efficient state for continuous traffic. The information given introduces the student to many avenues of practical value and observation towards solving the problem involved.

Some reference might have been made to the often observed corrugations of road surface and the probably contributing causes which have so far not been definitely determined.

The notes on page 4 about the correct weight of road rollers are very much to the point. In many cases the " disturbing " effect of road rollers of excessive weight to both foundation and surface has received but little attention.

Chapter V, which refers to roads during minor military operations, is an admirable compilation. It would have been of considerable assistance if some data could have been given in tabulated form showing the approximate cubic measurement, weight, and truck loads of metal and surfacing materials required per 1,000-metres', or yards', length of road as a guide for the Engineer Officer engaged in making a new macadam road during minor military operations.

Deserts of sand and stones and how to cross them are a new feature in road work, the outcome of the desert campaigns in Egypt, Sinai, Southern Palestine and Iraq, etc., during operations 1916–17–18. The credit for the application of wire netting for the purpose of making communication across desert wastes and sand fit for light motor traffic, lies with the officers of the Corps of R.E. Wire netting was employed for sundry purposes in Gallipoli and for crossing dry river beds in East Africa very early in the Great War. The first use of wire netting in

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Egypt was for laying pathways between hospital tents at Mehemdiya —east of the Suez Canal—and at Divisional Headquarters near Rafa early in 1916. Subsequently the tarpaulin floors of hospital marquees were laid over wire netting to prevent them from sinking into the sand. The use of wire netting was extended to local communications between Brigade and Divisional Headquarters in desert camps, and finally for evacuating the sick in Ford ambulance cars along main routes following the advance of the Expeditionary Force across the Eastern Desert into Southern Palestine. These wire roads were employed later on in other theatres and so formed a distinct feature of novel communication in the Great War, but they have not received the full appreciation they deserved.

*Plate* XVIII shows an actual wire road in process of construction close upon Gaza on the second day following its capture in November, 1917. The sparse brushwood and scrub over the alignment was roughly hacked down and cleared of tussocks, the sandy surface being made fairly even as a preliminary to the unrolling of the wire netting, which was rapidly laid, pegged down and fixed as described on page 55.

It is important to remove any large isolated hummocks and stones which may occur on or under the surface, as these will rapidly wear holes through the netting; if not quickly removable they should be crushed with a sledge hammer. Wire roads require careful inspection and immediate patching where any such holes or breaks in the netting take place: but careful laying and pegging down in the first instance reduces the risk of such breaks to a minimum.

Earthen roads in places where stone is absent are unavoidable *faute de mieux*. On all such roads a reduced speed is obligatory when they are used by heavy mechanical or motor lorry traffic—otherwise their destruction is rapid and irremediable for months.

Chapter VI, which deals with Roads and Communications during Stationary Warfare, is of no less importance than Chapter III, and the two should be read in conjunction. The chapter is a very useful contribution from experience gained in France and Flanders, and constitutes a valuable asset and fund of information for future operations. *Plate* XX gives useful information on how to repair shell-holes, and *Plate* XXI an example of a forward road system, the governing principles of which should be carefully studied by officers of the General Staff, R.E., R.A., R.A.S.C., Transport and Supply units, as this matter considerably affects military operations.

The screening of roads to counter enemy observation of troops, etc., in movement is one which was extensively used in Palestine and on the Western Front. In providing screens, ordinary rabbit wire netting enters largely into the construction whereby variations of foliage and screens can be applied to suit the backgrounds at different seasons of the year. Various types are illustrated, *Plates* XXIII, XXIV and XXV.

Chapter VII is one of a special character and of considerable importance to all engineers, pioneers and others who have to lay out and construct roads on hilly and mountainous country. The principles given are the result of many years' experience and collated from records of mountain roads in diverse parts of the British Empire, notably India,

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Tibet, Kashmir, N.W. Frontier, and also from observations made in the Caucasus (*Plates* XXIX and XXXV). Section 41 on Drainage is of great importance: neglect of efficient means for carrying off water has in the past led to great damage and disastrous hindrance to traffic. Other matters which concern mountain roads are collated in a very practical manner, *e.g.*, Causeways—Avalanches—Landslides, etc., and, not least by any means, namely the recruiting of road labour; organization, management of same.

Chapter VIII is devoted to masonry structures in road work, viz., Bridges, Culverts, Retaining Walls, Flood Openings, Scour in Rivers, and the like. Various formulæ are given, more or less reliable in character, for estimating discharge from catchment areas and requisite flood openings; but, it must be remembered that all formulæ have their limitations, being usually based on assumptions which may have particular application and cannot be relied on in general. All such formulæ should be qualified by the most recent records which can be obtained from publications of the Institution of Civil Engineers. (See Papers Nos. 4,452, 4,473 and 4,489). The practical rules and tables for masonry arches based on Trautwine's rules are quite reliable, given sound materials and workmanship.

Chapter IX—the last—is one which leads up to the type of permanent roadway which one may expect to see provided in future, namely the reinforced cement concrete highway.

The road question, affected as it is to-day by the ever-increasing loads in vehicular transport, is both vital and urgent. Hitherto engineers have only been able to meet the demands to a small extent. It must now be recognized that the increasing loads and traffic demand reconsideration of the problem and its answer on a vast scale. The reinforced concrete road is the nearest approach to the ideal highway and bids fair to solve the problem both as regards strength, surface, durability and ultimate lasting quality. Concrete roads have the merit of being free from deformation, corrugation and wave action; they are more stable, lasting and obviate "tracking," besides offering a good surface and small resistance to traction.

They have been in use in America for some twelve or more years, and at the present time their aggregate length approaches 60,000 miles. Meantime but little has been attempted in the U.K. (only since 1912), though during the last four years considerable development has taken place. Good concrete roads are to be found near Tilbury, Manchester, Sheffield and Middlesbrough. In the more recent and new routes all pipes for water and gas and electric cables are laid in culverts under the footpaths. A Report upon the proceedings of the recent Road Congress at Seville, May 1923, is worthy of reference in connection with concrete roads. (*R.E.J., September*, 1923.) Useful information may be obtained from the Concrete Utilities Bureau, 25, Gt. St. Helens, London, E.C.3. One of the most recent systems of reinforcement in use applicable to roads is ordinary "black sheet iron" stamped out to a special pattern, used by the Rogers Construction Co., 20, St. James Square, Pall Mall.

Where reinforced Concrete Roads are to be laid the use of "Ciment Fondu," an alumina cement, should produce much better results than

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ordinary P.C., inasmuch as the material develops in 48 hours a greater strength than P.C. after 28 days, whilst its rate of initial setting is slower, thus enabling the concrete to be handled for a longer period than in the case of P.C. "Ciment Fondu" would be invaluable in forward areas for roads which could be used sooner after completion than where ordinary P.C. is employed. For further information on "Ciment Fondu" see the *R.E. Journal* for September, 1923, pages 419–29.

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## MANUAL OF MOVEMENT (WAR).

H.M.S.O. Price 1s.

(From *Modern Transport*, 16th February, 1924.)

BOOKS issued by the War Office appeal as a rule to few readers outside the Army, but this one which has recently appeared is likely to prove of interest to a much wider circle. In war time the Army must rely in the first instance on existing transport systems, and if it establishes systems of its own, whether ox transport as in South Africa, inland water transport as in Mesopotamia, or extensive railway systems as in Palestine and France, it can only obtain the personnel for working them by drawing on civilian sources. The Army view, therefore, of how the best use can be made of existing systems and how military systems extemporized in war time can best be organized should prove of interest to everyone whose everyday business is transport of any kind. The importance attached to the subject by the military authorities is shown by an order that every officer is to be in possession of a copy of the book.

The book begins by dividing the operation of supplying an army overseas into five stages—collection from depôts at home and movement to a port, sea carriage, removal to main depôts, dispatch from these depôts by trunk services, and delivery at the front by distribution services. Then it names the transport agencies, from native carriers to aeroplanes, which may be employed. These may be existing systems under civilian management or services organized by the Army itself.

Considerable space is devoted to "Control." The loose use of the expression "military control" is responsible for much apprehension. Except where a transport agency is organized by the Army itself, military control does not mean control over the agency itself nor interference in the way it does its work, but control over the military demands made on the agency. In war time urgent demands are made by forces in the field on the depôts from which they are supplied, and the depôts do their utmost to load up goods to meet the demands. But neither the unit making the demand nor the depôt meeting it think much about how the goods demanded are to reach their destination. Different military supply departments compete for the facilities offered by some transport system, so that the sum of the demands frequently exceeds the carrying capacity of the system. The carrier is not in a position to say which consignments should have preference; no one but the

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C.-in-C. (or his mouthpieces, the staff) knows which is the more necessary in view of his plans. The object of a military controlling staff is not to interfere with the working of the system, but to collect and co-ordinate all the various military demands, to decide and to tell the management which are to have preference, and to issue orders to military consignors as to what they may, and what they may not, offer for dispatch. This has always been the real business of a Railway Transport Officer or of an Embarkation Staff Officer; but to make their functions perfectly clear and to strengthen their control over military consignors they all now form part of a new branch of the staff of the Army, the Movement Control Staff. As members of the headquarters staff of the Army, they speak in the name of the Commander-in-Chief, and the old-time R.T.O. is now invested with the authority of a representative of General Headquarters.

After an outline of the objects and duties of the control staff, the manual goes on to deal with the basic principles applicable to every form of transport. To obtain the maximum output from any transport system used for military purposes six conditions must be fulfilled. They are :—

1. Unity of control, *i.e.*, a single military authority to control demands and a single technical authority to control the working of a whole system.
2. Non-interference with either the technical appliances or the technical management.
3. Reasonable regularity in the demands made on each system.
4. Adequate running facilities with equipment to match.
5. Ample terminal and transhipment facilities.
6. Full use of the capacities of the system, viz. : (i) Full loads of the vehicle and of the motive power. (ii) Quick turn-round. (iii) Movements :—

(*a*) Continuous in time, *i.e.*, neither the vehicle nor the motive power ever idle, and in space, *i.e.*, across the gap between the two termini at points of transhipment.

(*b*) In one direction, *i.e.*, on single lines or on narrow roads or canals by the use, wherever possible, of alternative return routes. (In the case of a double line of railway or of an ordinary road the return route is parallel and alongside the outward route.)

(*c*) At uniform speed.

(*d*) Over the full distance.

(*e*) Balanced.

Considerable space is devoted to these principles and much more might be said about their application to all the various forms of transport which might be used. To some they will appear truisms, to others counsels of perfection, but it is to disregard of one or other of them that transport difficulties in past wars can invariably be ascribed.

Chapter IV deals with movements in a theatre of war, naming the various points to be watched by the control staff to ensure that the working of transport services is not hampered by any action on the part of the Army at variance with the principles of efficient movement

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laid down in Chapter III. The control staff can insist that military traffic of all kinds has priority over civil traffic (including civil passenger traffic), and, with a view to the control of civilian refugees or spies, may impose conditions as to their conveyance, but, with these two exceptions, the orders of the control staff are issued to military passengers and consignors alone, not to the technical management of the system. The next chapter deals with sea transport. It is noticeable for the stress laid on the importance, firstly, of using transit sheds for transit alone, and, secondly, on the discharge of cargo being placed under expert management and not left to the branch of the army to which the cargo is consigned. In small wars prior to 1914 we "muddled through"; in the late war the only sound system for the transfer of goods from sea to land emerged plainly, not only in the French and other ports such as Basra, but in landings on open beaches like those of Gallipoli as well.

Chapter VI deals generally with trunk systems—railways and inland waterways, Chapter VII with distribution systems—road transport and light railways. The subject of Chapter VIII is the organization and functions of various military transport directorates. It defines the position of a Director of Transportation in a small war or of a Director General when the extent of the operations warrants the appointment of one. A certain amount of semi-technical information is given, notably on the chronic shortage in war of railway wagons and the steps that may be taken to relieve it; also on the design of new lines and sidings for military purposes. Provision is made for a parcel agency for dealing with small consignments, the lack of which has been acutely felt at the beginning of every modern war, and the functions of the Docks Directorate are described. The remaining Chapters, IX to XII, deal with miscellaneous subjects, transportation in small wars and in position warfare, the transport of sick and wounded, artillery on railway mountings, etc.

Two or three main ideas crop up again and again under different aspects throughout the book. One is that the problem of transport in war has two different sides. On the one side fall questions of how transport systems can best be used to further military aims, on the other technical questions of how any particular transport system is actually to be worked. The former is the province of the staff, the latter is a problem for the technical management, be it civil or military, of each particular system. Though not always quite consistent, the book starts by labelling the two sides of the question with different names. Transport is carriage effected by a single agency, road, rail, inland water or other; transportation is defined as the use of agencies, either singly or in combination to effect transport. In other words, from the military point of view, transportation is not transport; transportation is the art of making use of transport systems; it includes the selection of the particular agency to be employed, the issue of orders to military consignors as to what they are to send and by what route, the ensuring of continuity at points where the form of transport changes as from sea to land or railway to road, and a variety of special arrangements for the health and comfort of passengers and for the safe transit of special classes of goods. These matters are duties of the staff;

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transport is the business of technical services under either civilian or military management. A transport service provided and manned by the Army itself is under a military director; its business is to supply or construct and to work some transport system, or to give technical assistance in labour, equipment or materials to an overtaxed civilian system. But as regards what such a military system is to carry and when and where, an Army system is in exactly the same position as a civilian system—it receives demands for carriage not from the military consignors direct, but from the staff.

Another idea running through the book is that, while every transport system is a potential weapon in the hands of a Commander-in-Chief in the field, yet to obtain the greatest advantage each system must be used in combination with other systems. Before the Great War there were one or two military text books dealing with particular forms of transport, but each was regarded as an entirely separate subject to be taken up by quite different people. The Engineer officer who had studied the use of railways for military purposes had little or no knowledge of the working of the mechanical road transport of the Army Service Corps. The late war brought home to the Army very forcibly that transport is a continuous chain of connected operations, linking the forces in the field to the factories and depôts at home, and that, however efficient any particular service may be, firstly each must be linked up with the next one to make a continuous chain, and secondly that the chain will be no stronger than its weakest link. In the pre-war organization one link was practically non-existent, viz., that joining sea carriage to land carriage; another, the connection between troops at the front and the railhead or riverhead from which they drew their munitions and supplies, was apt to be weak. And wherever one link was weaker than the previous one, congestion arose with the possibility of failure at a critical moment.

No two wars are ever the same, and even in the same war the lessons learnt in different theatres sometimes appear contradictory. In the late war the military transport problems on the Western Front, in Palestine, in Mesopotamia, in East Africa and elsewhere were quite different; all of them differed from the problems, say, in Egypt in 1884, South Africa in 1900, or on the north-west frontier of India at the present time. Those in the next war will be different again. There is a natural tendency to base opinions on one's own experience, and often the narrower the experience the more pronounced the opinions. This book is based on the experience not of one theatre, or even of one war. There is hardly a paragraph in it which is not founded on some actual occurrence in war time. It is an attempt to sift out principles from an immense amount of detail and then to lay down only such principles as are true, not merely under the special circumstances of some particular campaign, but those which will be true in any future campaign in whatever part of the world it may take place.

A. M. HENNIKER, *Colonel.*

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# *MAGAZINES.*

## *THE FIGHTING FORCES.*

Vol. I., No. 1., March, 1924. Edited by Lieut.-Colonel F. E. WHITTON, C.M.G. Gale & Polden, Ltd., Aldershot. Price 5s. net.

IT is believed that the orthodox comment upon a new periodical is that it " fills a long-felt want." It is not clear what want our contemporary *The Fighting Forces* is designed to fill. Its attractive cover tells us that it is "*A Quarterly Magazine for the Royal Navy, the Army and the Royal Air Force*"; but it contains articles on such a variety of subjects that one is inclined to doubt whether it will, as a whole, be of real interest to the special public for which it is intended. It may be taken as an axiom that, for a magazine to pay, every subscriber must find at least half the articles in each issue of direct interest to himself. If this condition is not fulfilled the number of subscribers will fall off. We fear that *The Fighting Forces* has spread its net so wide that many of the fishes will escape through the meshes.

The articles themselves are of a high standard, and many of the contributors are well-known authorities on the matters about which they write. There are serious articles on questions of general interest, such as *The European Outlook* by Professor Pollard, and *Security for France* by Général Fonville. These two articles give the two opposite aspects of the French policy since the Armistice and, taken together, give the reader much food for thought. There are articles which are mainly of Naval, Military or Air Force interest, such as *The Air Situation of the British Isles and Empire* by Admiral Mark Kerr, *Britain's Air Problem* by Brig.-General Groves, *The Indianization of the Indian Army* by " Silladar." There are articles on sport, such as *Services Rugby* by Lieut.-Commander Davies, *Coaching in the Services* by Major-General G. H. A. White, *Hunting for Infantry Subalterns* by Major Tomes. There are historical articles, a short story, a poem, hints to house-hunters, a guide to Plymouth, and other excellent reading matter which it is hard to classify. Even the auction bridge and chess enthusiasts are catered for. Reviews of about a dozen books, mostly of service interest, appear at the end. Many of the articles are well illustrated.

A pleasing feature of the publication is the brevity of the articles, few of which exceed 10 pages or 5,000 words—an attribute which is not common in service periodicals generally.

The magazine is well printed on good paper, Royal octavo size, and the first number contains, apart from advertisements, 168 pages of reading matter. It is to be published quarterly, in March, June, September and December.

G.E.H.S.

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### *REVUE MILITAIRE GÉNÉRALE.*

(*January*, 1924).—*To-day's Duty*. In this article Capt. Charles Delvert points out the needs of France in the matter of additional canals, railways, and deep-water ports, plans for which have been under consideration for years, and many are already worked out in detail. Also three-quarters of French maritime commerce is carried in foreign vessels. Taxation presses heavily on the people even if reparation payments are secured from Germany. The nation is falling behind all her neighbours in the struggle for existence. The only remedy for this disastrous state of affairs is more men, whereas at the present time the birth-rate barely exceeds the death-rate. The article ends with an appeal to the mothers of France to rescue their country by bearing larger families.

*Was it a Mistake to Retire the Belgian Army on Antwerp in August*, 1914? By Colonel P. Nuyten, of the Belgian General Staff.—An editorial note states that this article was first published in the *Bulletin Belge des Sciences Militaires*, and is a reply to the article by Capt. Kuntz published in the *R.M.G.* in May, 1923. It regrets that the Colonel chose a Belgian magazine in which to state his case, instead of relying on the impartiality of the *R.M.G.* The writer takes all the arguments of Capt. Kuntz, and refutes them categorically. He marshals his facts skilfully and seems to prove that, not only did the action of the King of the Belgians, against the entreaties of the French, conform to the maxims of Napoleon, and follow out the instructions actually given by Napoleon to Macdonald in similar circumstances during the campaign in Belgium just 100 years before, but was in the highest interests of the Allies so long as communication with the latter could be maintained. The serious menace of Antwerp on their flank was so clearly acknowledged by the Germans that their first care, after suffering defeat on the Marne, was to lay siege to it. Its importance was equally recognized by the British Admiralty as constituting the true and most advanced possible pivot of the Allied left flank. The occupation of Antwerp was not undertaken, as has been averred, to defend "the national refuge," but to make use of its strong positions to aid the field army in its resistance to the German attempt to envelop the Allied flank. (*To be continued.*)

*Ludendorff's Strategy on the Russian Front*. The conclusion of the article by General Camon.—Ludendorff in July, 1915, again advocated his plan of annihilating the Russians by cutting their communications through Kovno–Vilna–Minsk, but Falkenhayn directed him to take part in the less extensive frontal and flank attack. This attained a great measure of success, but Ludendorff argues in his "Memories" that his own scheme would have given more decisive results in a shorter time and at less cost. Falkenhayn claims that it was impossible to annihilate the Russians owing to their immense numerical superiority and excellent lines of communication, but at least they had lost 750,000 prisoners, masses of material, Galicia, Poland and Courland, and had been unable to threaten Austria at the opening of her war with Italy. It was not until August that Ludendorff obtained leave to execute his

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plan, and by that time it was too late. The Russian retreat had progressed so far to the East that the attack intended to fall on their rear now only reached their front and flank, so that again they were able to escape the noose. Owing to this, and that Ludendorff could never obtain the number of troops he required, and partly to difficulties of supply, the attack failed to be decisive.

*The German Infantry.*—The article by Commandant Pujo is concluded, and this month deals with the second and third phases of the attack. The following points are noteworthy (1) the exceedingly methodical manner with which all possible changes in the situation are provided for, and the thorough training instituted to educate all ranks to meet them almost automatically, (2) the large numbers of firearms allotted to the company, from accompanying artillery and heavy machine-guns to light automatic weapons, rifles and repeating pistols, (3) the strength of the staffs, officers, N.C.O.'s and men, allotted to all units, from the regiment to the company, and means of communication including small wireless telegraph sets, telephones, optical apparatus, cyclists, runners and dogs. The principle acted upon is that, once the action is begun, commanders in rear can see and know little of what is going on, those on the spot must therefore be in a position to act at once with the most powerful means required to meet the local contingency. All the higher commanders can do is to send up reinforcements of men, machine-guns, minenwerfer and, in case of need, guns, which the junior commanders make use of, and this is particularly requisite in the second and third phases, *i.e.*, from 400 yards into the position. This conception of the action is particularly suited to the war of movement; in short, the Germans realize that for many years, certainly as long as France holds the Ruhr, they cannot hope for material superiority, and aim at making up for this by the action of infantry of the highest military efficiency, which in the next war may thus be able to capture its material from the enemy. The whole article is well worthy of study.

*Position and Open Warfare* By Lieut.-Colonel Lucas. This article is an argument in favour of differentiation in the military regulations between these two classes of warfare, for, although the end aimed at is the same, viz., the destruction of the armed forces of the enemy, the processes by which this end is attained are very different in each case. The writer would have the regulations begin with the principles generally applicable to all cases likely to arise, and then be divided into two perfectly distinct parts. This would not only emphasize the differences of method, but would facilitate training in both types of warfare, and the preparation of schemes for exercises and manœuvres.

(*February*, 1924.)—*The Germans as Painted by Themselves.* By Albert Pingaud.—After describing the effects of their history and geographical position on the character of the Germans, the writer states that owing to these many causes they are exceedingly sensitive to the opinions of others, and show much of the snobbishness of the *parvenu*; frankness deteriorates into rudeness, intimacy into lack of reserve, differences of opinion into aggressiveness. The old German virtue of kindliness has been dulled by the grimness of the struggle for existence, and the historian Lamprecht avers that the old imperturbability, of

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which Bismarck afforded such a brilliant example, has given place to a nervous excitability. Many German writers who have had opportunities of comparing their compatriots with other nationalities, feel with keen regret the extent to which the former are disliked, but almost all attribute this to jealousy of German progress; only a few of them recognize any personal defects in the German character and in their manner of dealing with other nations.

*Was it a Mistake to Withdraw the Belgian Army on Antwerp?* The conclusion of the article by Col. Nuyten.—The two sorties of 25th to 26th August and 9th to 13th September, when the forces in contact at Antwerp were nearly equal, and active operations continued until 30th September, diverted from the German line on the Marne and Aisne the 9th Reserve Corps and several divisions of other Corps. Had the Belgian Army been at Mons or Tournai on 24th August, von Kluck could have masked the fortress troops at Antwerp with a few Landwehr units, and would have had the 3rd and 9th Reserve Corps to reinforce his right, which might then have been extended to Boulogne and Abbeville. From 15th September the German force at Antwerp was definitely superior, and the Belgian Army resumed its rôle of general advanced guard. On 29th September began the change of base from Antwerp to near Ostend, proof positive that the King never intended to identify the fate of his field army with that of the fortress. The arrival of Winston Churchill on 3rd October with a Naval Brigade stiffened the resistance of the Belgians, but they were slowly forced back, although reinforced by more British units, and by Allied troops sent to hold Ghent. If Ostend and Zeebrugge were lost it was due to the fault of the Allies in withholding adequate reinforcements, which were available in England, by means of which their front could have been extended behind the Dendre, Scheldt, or even the Lys, to join with the Belgians. But for the stubborn resistance of the Belgians at Antwerp it would have been impossible for the Allies to concentrate on the Yser and at Ypres by the 18th October enough troops to stop the progress of the Germans; and Dunkirk, even Calais and Boulogne, might have been lost. Col. Nuyten then vindicates the natural desire of the Belgian troops to defend their national soil as long as possible, and argues that any other nation would have done the same in like case.

*The Russo-Rumanian Campaign of* 1917. By Col. Bujac.—Commencing with a sketch of the situation caused by the evacuation of Wallachia by the Russians in December, 1916, and the successful efforts of the French General Berthelot during the winter of 1916–17 to restore order in the Rumanian Army, the events of the first half of 1917 are shortly described, including the effects of the Russian revolution. The battle of Marasti (Mamaia) in July, and the early stages of the battle of Marasesti in August are then described in greater detail. It is impossible to follow the account without a good map, which is not supplied. (*To be continued.*)

*Grand Manœuvres, what they were, what they are, and what they ought to be.* By Lieut.-Colonel Jèze. After considerable criticism of past and present methods of conducting manœuvres, the writer argues that the aim of grand manœuvres should be the continuation of instruction.

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Manœuvre areas should be close to garrisons, or, if more than two marches away, troops must be conveyed to them by rail. A review to close the operations is to be deprecated. Two complete opposing bodies are inadvisable, one should be a skeleton force operating under orders from the Director. Too much care for reality should be avoided if it interferes with the main object—instruction. Each day's operations should be divided into phases carrying out a definite programme, each phase followed by a rest affording time for criticism or, in case of need, repetition of a phase badly executed. The best way to simulate casualties is to fall out a less or greater percentage of the unit penalized according to the gravity of the fault committed. It is essential that the umpire staff should be ample and expert, and should comprise officers to accompany the higher commanders and follow the operations, and able to communicate with the Director and umpires.

*Books. La Campagne de Macédoine.* By Col. Feyler. Editions d'Art Boissonnas, Genève.—The second volume of Col. Feyler's book, relating events from the abdication of King Constantine and the intervention of Greece on the side of the Allies to the end of the war, is quite as good as the first volume, and is illustrated by carefully-selected photographs.

(*March*, 1924.) *Our North African Races in the New Army.* By Lieut.-Colonel Clement Grandcourt.—After a short dissertation on the services rendered to France by her so-called black troops, and the increasing need for their employment, even in the Mother-country, the writer proceeds to investigate the dangers possibly inherent to training for military service any large proportion of the youth of subject races of prolific and warlike stock, and suggests means for minimizing these dangers. He treats only of the infantry and cavalry—tirailleurs and spahis—of Morocco, Tunis and Algiers. Recruiting is mainly by voluntary enlistment, but latterly increasing recourse, especially during the war, has been made to conscription. The latter is becoming more and more unpopular, and for many reasons should be abated except in principle, since it may be necessary to apply it in case of war. The conscript is beginning to ask why he should be made to fight in a cause which may not directly concern him, and seldom re-engages. The volunteer or professional soldier frequently re-engages, after completing his four years with the colours, for 12, 16 or even 25 years, and makes an excellent soldier. It takes a few years to develop the native physically and technically, and the conscript, who serves for three years for less pay than the professional, and for a bounty of 250 francs, is barely trained by the time his service is completed. The professional soldier costs more in pay, his bounty is 500 francs, and there is his pension to consider, but he makes a smaller demand on the youth of the nation owing to his habit of re-engaging—instead of having to be replaced every three years, he serves for an average of 10 years. This makes a great difference in the cost of transport when he serves overseas, which almost cancels financially his higher cost under other heads, besides his greater military value. (*To be continued.*)

*The Attack of the 10th Colonial Division, 25th December*, 1915. By Commandant Janet, from documents of the Historical Service, and

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information supplied by combatants.—This action took place during the battle known to the French as the second battle of Champagne. After shortly describing the general situation and disposition of the French forces, the writer traces in more detail the fortunes of the 10th Colonial Division, part of the first line on the right of the 4th Army. The Division at first overwhelmed the German first position, and the intermediate position some 600 to 1,200 metres from it, but was checked in front of the second position, which, two to three kilometres from the first, was situated on a reverse slope and had been insufficiently bombarded during the artillery preparation. From 1030 to 1530 hours the attack seems to have been held up by reason of the French artillery fire on the German second position being aimed too short; at the latter hour it was decided that the offensive could no longer be continued owing to the physical and moral state of the troops, absence of reserves, to the right flank being uncovered, want of information on the general situation, and the renewal of activity on the part of the enemy. Two good sketches illustrate the article. (*To be continued.*)

*The Russo-Rumanian Campaign of* 1917.—The conclusion of the article by Col. Bujac, completing the account of the battle of Marasesti, a dearly bought victory for the Rumanians assisted by some Russian troops. As with last month's article, the operations cannot be intelligently followed owing to the absence of a map.

*The Campaign of* 1679. By Capt. H. Delschinger.—Describes how Louis XIV. compelled the Great Elector to confirm the Treaty of St. Germain. Accompanied by two good maps, the article is of historical interest. The moral the writer draws is that, to overcome a threatening and treacherous Brandenburger he must be held on the Rhine.

*Books.*—The following are favourably reviewed:—

*L'Evolution des idées tactiques en France et en Allemagne pendant la Guerre.* By Lieut.-Colonel Lucas (Berger-Levrault).—Readers of the *R.M.G.* will have already seen these pages under the title "*La refonte des réglements et notre doctrine de guerre*" ("The Revision of the Regulations," *R.E.J.*, July, 1921, *et seq.*).

*Napoléon et l'Amérique.* By A. Schalk de La Faverie (Payot).—This work fills a gap in history by tracing the influences of America on the destiny of Napoleon, and *vice versa*, and is particularly interesting at the present time when it is so necessary for the French to understand the aspirations and mentality of Americans.

*L'Enigme du Rhin.* By Major Victor Lefébure (Payot).—Chemistry played an important part in the last war, and will probably play a still larger one in wars of the future. The author demonstrates the powerlessness of the Treaty of Versailles to prevent chemical armament in the Reich, and consequently the facility with which Germany can equip herself in time of need. The remedy for a situation so full of danger, he considers, is to be found neither in limiting the number of factories, the production of which can always escape control, nor in any possible system of inspection, but in the development of their chemical industry by the Allies in proportion to that of Germany.

A. R. REYNOLDS.

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## *REVUE DU GÉNIE MILITAIRE.*

(*July*, 1923.) *A Discussion on Dug-Out Roofs.*—As a result of a difference of opinion between two officers, during the war, as to whether roof timbers or girders should be placed on edge or on the flat, the author, Lieut.-Colonel M. Tricaud, analyses the effect of concussion in such cases. He points out that, though the resistance varies as $\frac{1}{y}$ for static loads, it varies as $\frac{1}{y^2}$ in cases of shock.

He then shows (1) that for rectangular sections it makes very little difference which way the girders are placed ; (2) that for I-girders there is considerable advantage in placing them on edge ; (3) that for channels there is less advantage and still less in the case of rails.

*Foreign Reviews* :—

(1) " The Effects of Bombardment on Namur and Antwerp," from *L'Artillerie Suisse.*

(2) " Portable Assault Bridges Made of Kapok," from *The Military Engineer* of March–April, 1923.

(*August*, 1923.) *The Lessons of the War on the Organization of Ground.* By Général de division Cabaud.—The article is written to discover the principles underlying the organization of ground as evolved during the war. These principles can be sought in the various orders, instructions and rulings published by commanders as the result of events, and of their analysis of the causes leading to these events, which were made possible by the documents and reports rendered to them.

Unfortunately, many of these orders are contradictory, probably due to the necessity of taking action without delay, with the result that conclusions were arrived at too hastily, conclusions which might meet the particular case but which events proved not to be capable of general application.

In June, 1918, the parts of the front which had not shifted, owing to the events of March and May, consisted of many successive lines highly organized.

On the 24th June appeared an *Instruction* defining Army lines and fixing their rôle :—In the highly-organized sectors the army commander could choose the line on which to give battle and was to cover his front with outposts, *i.e.*, the limited withdrawal. The *Instruction* goes on to say that in newly stabilized sectors, as long as the enemy is not ready there for an attempt to break through, there could be no question of giving up more ground, and the dispositions must be different. The Instruction does not say what these dispositions must be.

The author goes on to say that it can be shown that the underlying principles remain always the same, modified by armament, stores, and circumstances. He then examines the regulations in force in 1914 under the following headings : (*a*) General, (*b*) Attack, (*c*) Defensive, and points out that these regulations could not have been as well known as they should have been. He draws a conclusion that the troops of all arms are capable of carrying out the works required under the regu-

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lations, but that it is absolutely essential that they should be trained and exercised in carrying out these works—the spade is as important as the rifle. He points out deficiencies in the *Regulations* which were issued to all officers, *i.e.*, the design of a strong point was given only in *l'Ecole de fortification de campagne* of 14th Nov., 1894, and no mention is made of the rôle of artillery in defence or the effect of artillery on the choice of a defensive position. These could be found, however, in the *Instruction* of 30th July, 1909, on Siege Warfare; all the principles enunciated in this *Instruction* were gradually rediscovered, for moving warfare, in four years of war, and their value confirmed by events.—(*To be continued.*)

*The Oilfields of Péchelbronn* (*Lower Rhine*). By P.J.D.—Sand impregnated with oil is found in pockets 2 or 3 metres deep, 30 to 300 metres wide, from 300 to 1,000 metres long, and at a depth of from 30 to not exceeding 600 metres. When pumping ceases to produce oil, shafts have been sunk into, and galleries driven just above these oil sands. These galleries have drains dug into the oil-bearing sands along which the oil can be drawn off.

Some 30% of the total oil in the sands is left behind, which at present cannot be profitably recovered by any known process.

(*September*, 1923.) *The Lessons of the War on the Organization of Ground* (continued).—The author then discusses the application of the principles. The *Instruction* of 1906 lays down that the object of fortification is to protect the soldier without hindering him from using his weapons. This should be enlarged to read all weapons, artillery, rifles, tanks, etc.

He points out that, though all the pre-war regulations laid down the necessity of outposts, it was not till 1918 that this principle was generally observed.

The outpost position should be deep, to give the army time to get into the battle positions, which should be out of reach of immediate assault, and sheltered from rifle and trench mortar fire.

It should be shallow, to reduce the number of men required to hold it to a minimum, and so that it can be supported by artillery placed in the battle zone, the bulk of which artillery must be able to fire two kilometres at least beyond the foremost line held by the infantry.

The bulk of the available resources must be spent on the battle position until this is completed, so that, at first at any rate, the outpost position must be very sketchy.

For the above reasons an outpost position would normally be 1,500 to 2,000 m. deep.

The zone covering the guns two to three kilometres and the artillery zone 3 or 4 km.

The outpost troops should fulfil their double rôle of delaying the enemy to gain time and of arresting hostile patrols; their rôle fulfilled, they should be withdrawn. This doctrine is always sound, and the organization of the outpost zone should be made with a view to its application. The situation changes when an army passes from the defensive to the offensive. In the outpost zone must be accumulated munitions and stores, trench artillery, assembly trenches, etc. This

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requires the front of the outpost zone to be strong enough to stop any raid, and the zone to be organized to meet the new requirements. To do this just before an attack would be to warn the enemy. The idea to aim at, therefore, is (1) to concentrate on the line of resistance till complete, and then (2) to organize the outpost zone with a view to an attack at some future date.

The writer discusses flanking fire and field of view, and then proceeds to deal with the question of continuous lines.

He points out that pre-war regulations specified fortified areas separated by intervals under observation and fire.

Continuity of obstacle, of communication and of observation is essential, but shoulder to shoulder defence should be avoided.

Next are discussed the necessity of defence in echelon, obstacles and the use of various parallels of defence. A second position, in 1914, could be 1 or 2 km. behind the first, now 7 or 8 km. is the minimum. More use must be made of natural obstacles such as streams, floods, marshes, and slopes which tanks cannot cross; these will have their effect on the siting of the line of resistance. Parallels of defence are indispensable for watching obstacles, for command, for communications, etc., but more is necessary to complete the organization of a defensive position, which must include complete disposition of fire, and the command of units, told off for obstinate resistance, by making a judicious use of accidents of ground in creating strong points, supporting points, centres of resistance, etc.

The trenches joining these points would form the parallels.

*Mines.*—The war shows that the results obtained from mining seldom justified the labour, materials, and explosives expended. Should the enemy be suspected of mining it is probably better to capture or destroy the works from which the mines start than to engage on counter-mining operations.

*New Principles.*—

(1) Protection from the air. This has become as important, if not more important, than protection from machine-gun and artillery fire.
(2) Gas protection.
(3) The equipment of back areas.

In conclusion the author points out that all the principles laid down in pre-war regulations have been confirmed, new weapons have introduced a few new principles without proving any of the old false. Details in the application of these principles change as weapons improve. It is impossible to lay down these details, and all officers must keep up with developments as published from time to time in technical papers.

*U-Frames for trenches in Reinforced Concrete.*—These are described in detail. They were used early in 1918, and proved excellent for reclaiming trenches or for use in really bad ground. Weight, 60 kilogrammes, or 53 (according to reinforcement); can be carried by two men.

(*October*, 1923.)—This number contains an account of the repair in 1915 of the bridge at Rethondes on the Aisne. This was an iron girder through bridge which had been cut into two parts, the larger

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weighing 105 tons and the smaller 26 tons. These parts were used in the reconstruction, the bridge being rebuilt on to an intermediate piled support. Excellent photographs illustrate the article.

It further contains a description of a light floating footbridge constructed with 3 runners and carrying a deck of light planks or of 2-in. or 3-in. diameter brush-wood in metre lengths. (This bridge is fully described on pages 297 and 298 of this number of the *R.E.J.*)

Such a bridge weighs 2½ kg. per metre, can be carried by 2 men every 5 metres, will support one man every 2 metres, and only requires 1 N.C.O. and 10 men to build 50 yards' run in 15 minutes.

(*November*, 1923.)—An article by Captain R. Villate on *Geology in War* mentions the introduction of geological units into the Allied and German Armies during the war and shows in what way information acquired by such units can be of use to armies in the field.

Colonel Lobligeois contributes an article entitled "A Study of Some Constructional Details." In this he describes improvements to, or new patterns of, mauls, heavy door stops, ablution benches, washing benches and shower baths.

The maul head is slightly conical in shape, with two iron bands to prevent the wood splitting. The act of striking tends to tighten the bands so that mauls so made do not split at all easily. The striking end of the maul head is flat, and the other round, so as to compel the use of the proper end.

*Foreign Reviews.*—Extracts of an article on "Pioneers at River-Crossings in the World War" from *Technik und Wehrmacht*, 1922, are translated.

The author describes various crossings, *e.g.*,

The Vistula, July, 1915,
The Danube, 1915,
The Duna, 1917, and
The Marne, 1918,

and then proceeds to draw certain conclusions:—

(1) That pioneers should be Jacks-of-all-trades and not specialists.
(2) The importance of instruction and practice in pontooning and rowing.
(3) That pioneers would tend to be employed more and more on the construction of heavy bridges, leaving lighter bridges to other arms.
(4) That it is a mistake to divorce the pioneer from his pontoons.
(5) The necessity of the provision of a couple of vehicles per company to carry such things as ladders, planks, pickets, floats (metal and otherwise), ropes, etc., if rapid crossings of obstacles are to be feasible.

C.LAT.T.J.

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## *REVUE MILITAIRE SUISSE.*

(1924. *Nos.* 1 *to* 3 *inclusive.*)

THE first parts of a valuable article by Colonel Grouard entitled *Le haut commandement et l'état-major* appear in Nos. 2 and 3 of the *Revue* for the current year. The contribution is not only of interest to soldiers, but would also prove instructive to statesmen and politicians would they take the trouble to read it. In the opening lines of his article, Colonel Grouard emphasizes the immense importance of placing the command of an army in the field alone in the hands of a really competent general and of giving him a free hand in the conduct of the operations. The question as to the limits both of the authority and of the responsibility of a Commander-in-Chief has frequently come into considerable prominence during the progress of hostilities. Colonel Grouard points out that the general functions of a High Command have remained unaltered throughout the ages, in spite of the fact that progress in the mechanical arts has, from time to time, brought about almost revolutionary changes in the armament and equipment of armies. The Great Captains of preceding centuries provided in their own time a sound solution to the problem relating to the rights and duties of a Commander-in-Chief in the field and have clearly indicated the region wherein lies the boundary between the functions of the political and the military chiefs of a State ; no sound reason exists for departing in our time from the practice introduced by them and acquiesced in by the statesmen with whom they had to deal. There are, Colonel Grouard freely admits, at periods of national crises certain questions relating to a prospective campaign which require to be considered at a round table conference attended by both the political and the military chiefs ; as, for instance, whether a war shall be conducted generally on defensive or offensive lines, and other similar questions. At such conferences the true sphere of the statesman is to lay down certain main principles of policy ; once these have been made known to the generalissimo and his acquiescence thereto obtained, the latter should be given full liberty of action as to the utilization of the means for waging war which it is proposed to place at his disposal and made absolutely responsible for all he does. A general in chief command should certainly never be hampered by political interference of any kind. The really great statesmen known to history have at no time attempted to meddle in a military situation during the progress of a war. In this connection Colonel Grouard cites the attitude taken up by Richelieu in 1640. In that year, the siege of Arras was entrusted to three Marshals who received intelligence reports indicating that a Spanish Army was marching to relieve the town. The Marshals could not agree as to the plan of operations to be adopted to meet the situation and referred their differences to Richelieu. The great statesman's reply was a simple one : " When the King," he said, " entrusted your commands to you, he believed you to be competent for your task. Please yourselves whether you advance or do not advance from your lines, but remember you will have to answer with the loss of your heads for your failure to take the town." A few days later, the Spaniards were decisively beaten and Arras carried by storm. Three decades later

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another type of statesman and another type of soldier were responsible, each in his own sphere, for the destinies of France. During the Dutch War, Turenne was in command of the French Army in the field and Louvois now attempted to interfere in the military plans; the great soldier firmly refused to be dictated to by the politician and conducted the operations according to his own judgment and received the full support of Louis XIV. Turenne's attitude during the latter part of the campaign of 1672 is well deserving of study, being worthy of imitation by every Commander-in-Chief. Colonel Grouard recalls other historical incidents and shows how serious have been the consequences where statesmen have failed to follow the example of Richelieu and soldiers that of Turenne; he points out, for instance, that France's misfortunes in 1870 were largely due to the "interference" of de Freycinet. Happily when the Great War broke out the political destinies of France were in the hands of a wise statesman; it is recorded that Millerand steadfastly refused to force his views on the French generalissimo, who had a perfectly free hand to act according to his own judgment during the early phases of the War in 1914. Unfortunately, at a later stage the politicians did not act with the same wisdom as Millerand and to the interference of Ministers are due some of the difficulties which produced critical situations on the Western Front. Obviously, in order that due recognition may be given by the statesman to the authority of a general in the field, it is necessary that those who are placed in command of armies in the field shall possess the necessary qualifications and qualities to carry out the tasks entrusted to them with success. Hitherto, the making and unmaking of generals has been a matter largely in the hands of politicians; unfortunately, they have not always been guided, when making their choice, by completely disinterested motives. It is no secret that a certain type of politician—call him statesman if you will—is terribly afraid of a really efficient and strong soldier; he looks upon the latter as a sort of potential Cromwell. The attitude of this type of politician is exemplified by a remark made, in all seriousness, just after the South African War, to a young officer by one who later became a Secretary of State for War; he expressed the view that the Army was a profession, and the only one, in which it was not necessary for a man to possess real ability in order to rise to the highest position. The line of reasoning by which such a conclusion was arrived at was probably based on the assumption that the failings and defects of a general in chief command can always be counteracted by giving him capable staff officers and, therefore, it is not detrimental to the interests of the State to place a mediocrity at the head of an army, so long as he is sufficiently pliant. This doctrine is, needless to say, a most mischievous one. A safeguard is absolutely necessary to prevent any but really competent soldiers being selected for high commands. Colonel Grouard definitely advocates a change in the present method of selecting generals; he would like to see political influences entirely eliminated in this matter. His view is, and it is perfectly sound, that only those brought up in a particular profession can properly size up a man following their own calling and assess his professional qualifications at their true value. Therefore, it is to the principal officers of an Army, acting as a committee,

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that he would entrust the selection of a Commander-in-Chief. Colonel Grouard seeks to indicate the signs by which the really capable soldier can be recognized; much that he has to say on this subject is of considerable practical value. He admits that there has at all times been a dearth of men possessing the qualities required in a Great Captain; and so far as France is concerned, in his opinion, it was alone during the periods of the Revolution and the Empire that it can be said there was a sufficiency of capable men from whom to choose the commanders of the important formations, but even in those epochs the majority of soldiers who rose to fame were only qualified to hold subordinate commands. In the period 1815 to 1870, only one soldier, Marshal Bugeaud, stood out conspicuously head and shoulders above his contemporaries; it is doubtful, however, whether he would have been competent to undertake the supreme command in an important war. Colonel Grouard considers that in 1870 all the chiefs of the French Army were mediocrities and states that during the first few months of the Great War more than 100 generals were deprived of their commands; some of them, in his opinion, unjustly, the most notable of these being Lanrezac, whose chief fault seems to have been that of possessing a clearer vision than the "pontifes du G.Q.G." No summary can do justice to Colonel Grouard's article; in order properly to appreciate its value, it is necessary to study the original and to learn the views of its author at first hand.

The article by M. Jean Fleurier entitled *Une Légende; La faillite de la fortification permanente pendant la grande guerre*, begun in the number of the *Revue* for October, 1923, is continued in No. 3 of the current year. The Defence of Liége is dealt with in some detail and the question examined as to whether anything which ought to have been done was left undone. M. Fleurier places on record his opinion on the defence; he unhesitatingly affirms that General Leman put up the best defence that was possible and he is satisfied that the forts at Liége, obsolete although undoubtedly they were, fulfilled a most useful purpose. Unquestionably, the Germans met with a serious check at Liége; they succeeded, it is true, in attaining three of their objectives, but partially only: (1) they forced the passage of the Meuse at Lixhé; this was due to the fact that the Belgian detachment at that point was not supported either by machine-guns or artillery and was out of reach of the support of the "forts de Pontisse"; (2) the passage of the Meuse at Lixhé permitted the XXIV. (Mecklenburg) Brigade to attack the Belgians along the left bank of the river on August 6th, and a German detachment thus managed to penetrate into Liége; it became, in consequence, necessary for General Leman to take refuge in the "fort de Loncin," a position from which he could not properly direct the defence; and (3) the XIV. Brigade under Ludendorff seized the "fort de la Chartreuse," which was not defended, and managed, in consequence, during the night of August 6th/7th to seize four of the bridges over the Meuse and the Ourthe within the town. A Table accompanies the original article; therein particulars are given of the part twelve of the detached forts played in the defence of Liége, the dates on which they fell, the casualties suffered, the damage done to the fabric, etc., being duly recorded. Under the heading "general conclusions," M. Fleurier points

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out, *inter alia*, that the Germans did not repeat, in their subsequent operations, the method of attack adopted at Liége ; no further assaults on forts were undertaken, but the German artillery was allowed to reduce the works by degrees with its fire. In many cases, the Germans did not completely invest the forts at Liége and, in consequence, the garrisons escaped therefrom and rejoined the main body of the Belgian Army. A detailed examination of the detached forts disclosed the fact that, in the case of six of them, the cupolas were not destroyed, but certain weaknesses developed in other parts of the structure, causing the cupolas in some cases to sink, whilst in others the turn-tables "seized"; all these defects were of a kind that could have been easily remedied. M. Fleurier recognizes that the essential question which requires an answer is: "Did the fortified position of Liége properly fulfil its rôle?" A quotation is given from an article entitled *Essai sur la fortification permanente moderne* contributed to the *Revue du génie militaire* (August to October, 1922) by Colonel Lévêque, who writes: "*Une place peut tenir un an sans utilité, et telle autre en résistant six jours assurera le salut de l'armée, ou imposera à une armée ennemie une manœuvre qui lui sera fatale.*" In order to find an answer to the foregoing question, M. Fleurier examines it in the light of the extract from Colonel Lévêque's article mentioned above and points out that the important functions of a fortress are (1) to delay an enemy ; (2) to cause him heavy loss ; and (3) to produce a moral effect. Short as was the siege of Liége, it delayed the Germans sufficiently long to give the French time to complete their concentration without disturbance ; undoubtedly, the Germans suffered very heavy casualties at Liége—the losses are not known with any exactitude, but have been estimated, perhaps too liberally, by the Belgians, at over 42,000 killed and wounded ; on the whole, the resistance of the Belgians at Liége had a good moral effect on the Belgian people and went far to inspire confidence in the Belgian Army. M. Fleurier thinks that Liége really played a more successful rôle than was anticipated by the military chiefs of Belgium. Among the important ends secured by the defence of the town were the following: (*a*) the Belgians were able to complete their concentration on the Gette ; (*b*) von Einem's Army was prevented from crushing the Belgian Field Army out of existence ; (*c*) the French, as already pointed out, obtained sufficient time in which to complete their mobilization ; and finally, (*d*) the British Expeditionary Force was able to land safely in France, and succeeded in reaching Belgian territory, where by taking up a position at Mons it materially helped to delay the advance of the powerful German Right Wing into Northern France, and eventually assisted in bringing about the discomfiture of the German hosts in the Battle of the Marne, 1914.

W.A.J.O'M.

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*BULLETIN BELGE DES SCIENCES MILITAIRES.*

(1924. *Nos.* 1 *to* 3 *inclusive.*)

THE account of the operations of the Belgian Army in connection with the Defence of Antwerp appearing in previous numbers is continued in those now under notice, the events taking place on October 5th in the

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sub-sector of the defence assigned to the 5th Division being duly chronicled. At this date, the Germans had reached the line of the Nethe and were attempting to force its passage, having already driven back the Belgian advanced posts. The defenders of Antwerp were now finding it difficult to maintain their communication services within the sub-sector and much time was, in consequence, being lost in connection with the transmission of orders and in passing reports laterally as well as from front to rear. The headquarters of the 20th Mixed Brigade had been established at the railway station at Contich; the choice of so distinctive a position for this purpose proved an unfortunate one. The German artillery quite naturally early turned its guns on to the station, bringing an effective fire to bear upon it. The result was that at 9.30 a.m. the Brigade-Commander and his Staff had to abandon their battle-headquarters, and, in doing so, left their maps and horses behind. It was not until nearly two hours later that a report was received from this Brigade-Commander notifying the misfortune that had overtaken him. The advance of the Germans to the Nethe on October 5th was to some extent favoured by a mist and they were also able to take advantage of the cover existing on the south bank of the river; it is stated that their movements could not be clearly observed from the position occupied by the Belgians. The German sappers were also able to utilize the Schollebeek for the purpose of constructing barrel piers in positions hidden from view. When completed, the piers were floated down into the Nethe and a bridge was thrown across in a bend of the latter river at a point some 800 yards from the south-west corner of Lierre. The Belgians did not discover the position of this bridge, and an airman who was sent to reconnoitre along the river definitely reported that the Germans had not thrown one across the Nethe. In the circumstances, no attempt was made by the Belgian artillery to destroy the structure which it is now known was put in position by the German sappers. The Germans crossed the Nethe near and in Lierre and extended westward along the north bank of the river and by midday their left flank had been pushed west nearly to Lachenenhof. The German bombardment was now beginning to tell on the Belgians and was proving disastrous to their morale. The German gunners were kept well posted as to the progress being made by their own infantry and they were, in consequence, able to render the latter effective support. The Commanders of the Belgian troops in the firing line were calling with greater and greater insistence for reinforcements: some of them do not seem to have had a real grip on the situation. The staff work was to some extent also faulty; the orders issued were occasionally ambiguous and necessitated an enquiry on the part of the recipient as to what exactly was required of him. Further, reports sent from the front line were not always framed with precision and due regard for accuracy; a false impression as to the true situation was thus created at headquarters. Towards the evening, the Belgians began to give way; in order therefore to steady his troops, the Commander of the Belgian 5th Division placed additional troops at the disposal of the Commander of the 1st Mixed Brigade and ordered him to undertake a counter-attack in the direction of Ringenhof - Ander-Stad. The troops of the Royal Naval Division

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under General Paris were at this time covering the left flank of the Belgians near Lierre.

An anonymous contributor deals in No. 1 of the *Bulletin* with land defence against aircraft attacks. In discussing the employment of anti-aircraft artillery he recommends that the first line A.A. batteries should be posted in groups at the angles of triangles. The bases of these triangles should be approximately parallel to the front to be defended. The actual position to be occupied by the batteries will naturally depend on the characteristics of the ground, the mission assigned to them, and the military situation of the moment. The interval between any two batteries on the base line, which should, it is recommended, be from 2 to 5 km. from the front line, is likely to vary from 2 to 5 km. ; the rearward battery of a group should be placed from 3 to 5 km. behind the base line. The author of the original article gives therein his views as to the methods to be adopted in handling A.A. guns ; in obtaining information concerning the movements of enemy aircraft ; and in transmitting the same to the A.A. batteries. He tells us that, in Belgium, the anti-aircraft searchlight unit is the battery of four sections, each section consisting of four projectors and one set of listening apparatus. The searchlight batteries are divided into two categories, namely, the " batteries de projecteurs de l'armée " and the " batteries de projecteurs de l'intérieur." The author of the original article emphasizes the importance of employing searchlights used in connection with aerial defence " in mass " so as to illuminate as large an area of the sky as possible, in order that enemy aircraft may not be able easily to avoid the lighted area, which should have such a depth that it may be possible for the A.A. guns or the defence aircraft formations to pick out the enemy's machines during the period they are in the illuminated field. Used singly, a searchlight becomes merely a navigation beacon and is, for defence purposes, worse than useless ; for this reason, the use of single projectors should be forbidden. The author of the original article predicts a considerable development in the near future of the use of " protective balloons " and also an extensive employment of camouflage in connection with aerial defence ; he points to the use made in Italy and France of " protective balloons " during the Great War and the useful results obtained therefrom. Those who are seeking information concerning the Fourth Arm in attack and defence will find much matter of interest in the article under notice.

Attention is called in No. 1 of the *Bulletin* to the Royal Decree published recently in connection with the reorganization of the Italian Army. Under the new law, a Supreme Council of Defence has been set up in Italy and comprises a deliberative committee, a consultative group and a general secretariat. It appears to be the intention of the new Government that in future the Minister for War shall always be a soldier ; he will in peace-time have under him (*a*) an Inspector-General of the Army, who will on the outbreak of war take command of the army in the field ; and (*b*) a General Staff, which on the declaration of war will automatically pass directly under the orders of the Commander-in-Chief of the Field Army. The peace-time formations formerly known as " divisions " have ceased to exist. The term " divis-

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ion " now designates a territorial area ; Italy has been divided into 30 such areas, which have been grouped into 10 Army Corps Commands. Particulars are given in the original article of the new organization adopted for the several arms ; the new organization of the Engineer Arm provides for :—A " superior directorate " for engineering services ; 10 Army Corps Engineer Staffs ; 10 Army Corps Engineer Groups, each consisting of a staff, a battalion of sappers and miners, a telegraph battalion and a depôt ; a radio-telegraph regiment, comprising a staff, 5 battalions and a depôt ; a pontoon and lagoon regiment, consisting of a staff, 3 pontoon battalions, a lagoon battalion and a depôt ; a railway regiment, comprising a staff, 2 battalions, a traffic group and a depôt ; 10 " Engineer Directions " ; a military institute of radio-telegraphy and electrotechnology ; and a workshop.

Captain-Commandant Menzel contributes to No. 3 of the *Bulletin* an article entitled " Quelques considérations sur les couverts " ; it should prove of particular interest to Sappers. Articles are also published in the numbers of the *Bulletin* under notice, *inter alia*, on the following subjects :—Aeronautics, a sketch map of the international aerial routes being given (Nos. 1, 2 and 3) ; the 1/40,000 relief maps of the Jurassic region of Luxemburg (No. 2) ; conversion of solid into liquid fuel (No. 2) ; the pacification of Morocco [a map illustrating the progress made by the French in the occupation of this territory accompanies the letter-press (No. 3)].

W.A.J.O'M.

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*LA GUERRA Y SU PREPARACION.*

[The following abridged translation of an article in " War and Training "—the monthly publication of the Spanish General Staff—for July, 1923, by General Avilés, contains some constructive criticism and an interesting speculation as to how the trench warfare on the Western Front might have been avoided by either side who wished to do so.]

*The Principles of Field Fortification in the light of the Great War.*—The transformation of the whole of the Western Front into an immense entrenched camp disproved by practice the theories of those who hold that fortresses are useless. These theorists take no account of the fortresses of North-Eastern France, which, in conjunction with the short (but sufficient) defence of Liége, imposed on the Germans a long and ex-centric line of invasion, and made possible the allied counter-offensive on the Marne. They demand of fortification what only men can give, forgetting that it is not the inert material which avails, but the courage and skill which utilizes it.

Fortifications have never been so abundantly or so badly used as during the years 1914-18, and, above all, on the Western Front, and from here emanate so-called " lessons," which should rather be termed " negations." Careful discrimination is necessary to separate true lessons from the mass of injurious " examples."

Whoever has attentively followed the unfolding of the operations on the Franco-Belgian front will sum up his opinion in the one word " con-

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fusion." Each and every one of the belligerents was seeking to achieve victory without exposing himself to defeat, without running the risks which are inseparable from military success. For years man was relegated to a minor rôle and victory was sought by the preponderance of material in an attempt to make war a simple mathematical problem from which the moral factor was, as far as possible, eliminated.

If we accept this conception as the last word in progress it is not worth while to study the military art, but fortunately history does not confine itself to this one period alone and teaches us that power is not measured solely by material but by the courage and training of the troops and by the ability of their leaders. The human factor has always occupied, and will continue to occupy, the first place.

The Western entrenched front was neither a good example of *Field Fortification*, which should be the servant of tactics, and tactics became impossible when the garrison of the uninterrupted front used up the whole of the available troops; nor of *Permanent Fortification* because it prevented the power of strategic movement, to facilitate which should have been its object.

Rather can we say that on these battlefields every branch of the military art lies buried with the flower of the youth of Europe. Our deductions must be rather as to what is to be avoided than as to what is to be imitated.

During the three months of the "race to the sea," the trenches were gradually prolonged from the Aisne to the Flanders coast, but still had not acquired the continuity which they achieved early in 1915. If either side had at that time abandoned the continuous line and grouped its forces suitably, leaving wide gaps between groups, the opposing side would have been compelled to conform, and a war of movement would again have resulted.

But, as stated above, each side was seeking only to avoid defeat.

It is surprising to note that on the Alsace-Lorraine front, where German inferiority was most marked, the French multiplied their works until continuous lines were attained. The Germans for many months remained faithful to the true principle of field fortification and maintained themselves concentrated in "localities" and not dispersed laterally.

The French forgot the true rôle of their Southern fortresses as "axes of manœuvre."

Such conditions of unturnable flanks, perfection of communications, unlimited material and reciprocal timidity are unlikely to occur in another war.

One important lesson of the war is to make it possible to define the differences between "*Rapid*" (or "battlefield") Fortification, "*Field*" Fortification, and "*Permanent*" Fortification.

*Rapid* Fortification develops during the shock of an engagement. Its end is purely tactical; it must be of quick execution and accommodate itself to the formations and incidents of the struggle.

*Permanent* Fortification strengthens points whose importance is strategical, making them into "axes" or "points" of support, or provides zones of security in which troops can be assembled for major

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operations directly destined to cover frontiers, close lines of invasion, or guard points of strategic importance.

It must be constructed before the outbreak of war, or at least before operations take place in the zone to be fortified. Its rôle is strategic and it has only a secondary influence on tactics.

*Field* Fortification shares some of the characteristics of the other two, having both strategical and tactical aspects. It is employed to strengthen points whose importance increases during a campaign, and which have to be occupied to free the bulk of the field troops for manœuvre elsewhere without weakening the front; or to prolong resistance in places which the enemy is bound to attack; to cover lines of invasion; or to cover a retreat or a movement.

It is clear that "rapid" fortification is confined to the slight modification of the shape of the ground, while "permanent" fortification admits, and even requires, the construction of works of great solidity and resisting power. "Field" fortification is a mean between the two.

According to these definitions the double Allied-German Western Front was of the "rapid" type which gradually tended towards the "permanent." Only at some points, mostly in the back areas, are genuine examples of "field" fortification to be found.

The primary object of each of the three classes of fortification is to enable the enemy to be attacked in the most efficacious manner. The protection of the troops holding them from enemy action is secondary. It is imperative that they should never be allowed to be an embarrassment and still less an impediment, to tactics or strategy. The power to modify the use of, or to abandon, fortifications constitutes an important auxiliary weapon in the hands of commanders, but it is necessary for troops to be trained so as not to lose morale in such circumstances.

Considered either tactically or strategically, field fortifications must be limited in extent and confined to those points on which attack is obligatory. Failure to observe this principle bears bitter fruit. A new "Wall of China" affords nothing beyond a modicum of moral sense of security to the defender. Tactically it gives to the battle front a uniform density which is the straight road to defeat.

When considering fortified "localities" it must be borne in mind that any area of less than 300 metres radius will be a shell trap, in which the power and rapidity of fire of modern artillery will in a few hours render life impossible except in deep dug-outs or shelters which require materials and time only available in permanent works.

Two means exist of neutralizing the effect of such a concentration of fire. The first is by counter-battery action, but usually the enemy will have concentrated sufficient artillery to ensure preponderance at the point of attack.

The second is by spreading the defended zone laterally and in depth so as to offer to the enemy a target disproportionate to his available ammunition supply and time.

Thus, the single positions of yesterday will to-day be, in principle, linked positions; and the single firing lines will become multiple.

We reach the conclusion that the redoubts of the past are no longer of use, and detached positions can only be effective in very difficult

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ground. In their place we require multiple organizations scattered and concealed, groups of positions which mutually support each other.

But, it may be argued, this multiplication of positions will lead to a multiplication of troops required to hold them, and thus annul the object of fortification; and this argument is worth due consideration. One positive lesson that the Great War has taught us is that a few machine-guns, or even a single one, can defeat the most resolute and well-prepared attack. Consequently numerical strength is not so necessary for the defenders as the judicious siting of a few machine-guns, served by cool-headed gunners, available at the right places at the right time.

Against distant attack—dissemination; against close attack—machine-guns. These are the two chief principles of modern fortification. In order that dissemination should not be a mere word it is imperative that the enemy artillery should be kept ignorant as to which of the various lines and localities presented to his fire are the ones vital to the defence; and that the nucleus garrisons in these should be kept sheltered from his fire; and that the machine-guns should be able to take up their fighting positions at the critical moment.

The technical troops enable this plan to be put into effect in accordance with the tactical and technical considerations.

Tactics lay down and define the principles of the defence; technique, following tactics, brings them into being.

It is not so important as formerly to have the ground traversed by the attack under direct fire from the parapet, and considerations of concealment would frequently render this impossible.

Consequently, in laying out a position, the siting of the machine-guns must receive first consideration, grouping them always in twos or threes to increase the probability of at least one being available when required. The most forward machine-guns should be sited first, and then others to their flanks and rear to protect them and enable the ground to be completely swept.

These machine-gun posts form the pivots of the defence. Then by means of entanglements and other accessory defences the attack is broken up and directed into channels, augmenting the efficiency of the machine-guns.

Thirdly, fire trenches and communication trenches are dug in such a way as to permit of a "step by step" defence, so that the loss of a portion of the position does not involve the whole.

The first object of the infantry trenches is to protect the machine-guns. They should mutually support each other and sweep the whole route of the attack.

The last step is to shelter the defenders from the enemy's fire. Sometimes this can be done by adapting natural features, at others, mined dug-outs, "elephant shelters," or such-like are necessary.

To conform with these ideas, a fieldwork of the future will not bear the least resemblance to the classic "redoubt." Its active portion consists in nests of machine-guns which completely sweep the interior as well as the whole of the front and flanks. The passive portion consists in dug-outs and shelters for the machine-guns and for the garrison;

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and, as a complement, a network of trenches developed on a scale much larger than is necessary for the effective rifles of the garrison. Communication trenches must be abundant, laterally and longitudinally, and there should be many " accessory " defences independent of the main trench system and well flanked. The whole must be well concealed.

The intervals between " localities " are usually left undefended, but are swept by the artillery of the defence and enfiladed and flanked from the localities. At times it is necessary to construct accessory defences to command them or to " shepherd " the enemy into the field of fire of the positions.

Translated by R. E. M. RUSSELL,
*Bt. Lieut.-Colonel.*

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*MILITÄR WOCHENBLATT.*

*10th July*, 1923.—The leading article of this number deals with the strategic use of the German cavalry in the Great War. Half the first column is devoted to explaining that, though Germany lost the war, the blame is solely attributable to the politicians. General Freiherr von Gebsattel then introduces the subject of the article by defining the following as mistakes, the avoidance of which would in all probability have given a more favourable issue to the war for Germany. The watering down of Schlieffen's plan and consequently the attack against the French fortress line of the Western front, the withdrawal of the reinforcements considered necessary for the East from the German right instead of the left wing, the loss of control of the first German advance by the German G.H.Q., resulting in the completely unnecessary retreat from the Marne, further the attack on Verdun not being conducted on both banks of the Meuse, and finally the false strategic employment of the German cavalry.

The author asserts that the German cavalry of 1914 was absolutely on a par with its sister arm the infantry, " unsurpassable in training and morale." After further eulogies he comes to the interesting statement, ' Hence the fact, which I had already prophesied some 20 years ago : nowhere have our enemies dared to oppose their cavalry mounted against the German." This statement has even drawn a footnote from the Editor, who points out that the same conviction that the German cavalry refused combat with the *arme blanche* to the French cavalry has already grown into a " legend " in French military literature. The author then goes on to assert that the leadership of the great cavalry bodies was as a rule quite skilful, instancing von der Marwitz's Corps in Flanders and Schmettow in Rumania. Everything in fact was at hand for exceptional performances by the cavalry except one thing, the lack of a chief completely saturated with the spirit of cavalry employment, who had soared above the views usual at G.S. and cavalry staff exercises, and who had produced new ideas. He then gives three situations in which the employment of cavalry by German G.H.Q. did not come up to expectations ; in the first and third he says their correct use would have decisively influenced the war, while in the second quite different results could have been achieved to what happened.

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The first case came about through the forward movement on the Western front. The great German cavalry bodies were spread over the whole front, only kept stronger on the right wing, everywhere allotted to the several armies. "What could cavalry Corps do which were wedged in between two close infantry fronts and, even if the enemy were beaten, must find an end to their activity at the latter's permanent fortifications?" All the reconnaissance could have been done by divisional cavalry and aeroplanes. The entire German Army cavalry, except what was necessary in the Eastern theatre, should have been concentrated on the right wing of the whole Army and have formed an independent cavalry force. At first a limited number of divisional cavalry could have been allotted to the 1st, 2nd and 3rd Armies as necessary till the main bodies of all arms had encountered each other, but then these bodies of cavalry also should have been withdrawn to the right and joined to the cavalry force. The latter would then have consisted of about six Cavalry Corps with the necessary Jäger battalions, cyclist and machine-gun units and one or two *Abteilungen* of heavy artillery.

Against the argument that there was no cavalry leader even trained theoretically in peace for such a command, the author says he can name at once three men fully up to the task. The achievements that this force would have won he gives as follows: to stop the withdrawal of the garrison of Antwerp, to locate definitely the enemy's left flank, to attack and destroy the retreating enemy: "never would the opponent have been able to attempt to press back our right wing, the separation of the 1st Army from the 2nd would have been avoided, the retreat from the Marne also would not have resulted through nervous leadership. Besides this Dunkirk would doubtless have been occupied, perhaps even Calais." And so the campaign would have been finished off.

The second case is drawn from the break-through at Gorlice on the Russian front, where he considers that a strong cavalry force of one to two Corps should have been held ready to exploit the break-through and complete the enemy's defeat. "As the decision of the war lay in the Western theatre, the final victory could not have been wrested by this," so he passes after but a short flight of fancy over the probable results to his third case, the spring of 1918 in the West.

"Had it been possible to get a strong force of cavalry into position at the advance on Amiens, then after the infantry and artillery had gained their victory the enemy's defeat must have been completed and Amiens would have fallen into our hands." End of the campaign and of the war. "The conditions were similar at the attack on Kemmel."

He then admits that there were gigantic difficulties to be overcome, drawing such great cavalry masses from the front, replacing them, concentrating them at the right place, pushing them up to the distance at which they could be used, and maintaining them there. In addition a large part of the cavalry, even if it had still the old spirit, was no longer at the pitch of excellence of 1914 by reason of its long employment in the trenches, so many horses had been given up, lost or replaced by inferior material.

The author then states that he yet has such firm confidence in the genius of their first *Generalquartiermeister*, that he would have succeeded

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in overcoming these difficulties if—" ah—if only he had at that time shared my conviction." .

*25th August*, 1923.—The most interesting article of this issue is a review of the 3rd volume of Count v. Waldersee's Memoirs. The first part of the volume deals with the China expedition of 1900, while in the second part German conditions up till the time of the author's death in March, 1904, are illuminated as with a prophet's vision.

As regards the Boxer rebellion, it notes that the Germans took no part in the looting of Pekin; while the German Field-Marshal claims that in the course of the fruitless diplomatic intrigues between the Allies he can claim to have earned some merit that open conflict between them was avoided.

The second part revolves round William II., and the " melancholy prophecy " of a general German collapse repeatedly occurs. " But nobody dared tell the Kaiser the truth; everyone agreed with him; nobody warned him that his policy was inconstant and double-tongued and must destroy all confidence." Though the War Minister v. Gossler told him that he was the only man who could speak out to the Kaiser, the Field-Marshal could not bring himself to do it. The reviewer, Lieut.-General von Altrock, deplores that, though the Field-Marshal foresaw the collapse even in the early years of this century and was a trusted friend of the Kaiser, yet he could not find the strength to bring the full weight of his convictions to the knowledge of his War Lord. For decades the old Army, from its foremost leaders to its youngest soldiers, had been brought up on the principle that sins of omission and neglect were far graver than those of failure in selection of method, and the reviewer condemns the Field-Marshal on these grounds. The last thing he wrote was: " I pray God that I shall not live to experience what I can see coming," and v. Altrock calls this a serious charge against its writer, the very man who should have stood up to the opposition and helped the truth to its rightful position.

E.G.W.

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*MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.*
*January–February*, 1924.

THIS number opens with an article on the supreme command of the allied armies of 1813. The question as to whether the supreme command of Prince Schwarzenberg was really unquestioned is one of academic interest only, and the author of the article, Dr. Phil. Egar Lauppert, does not throw much light on the subject—but he gives some interesting details of the intrigues of Metternich, Stackelberg, Nesselrode, Stadion, etc., and quotes a long list of authorities.

Colonel Fleischer describes his adventures as a regimental officer in the 1914 retreat to Przemysl.

Major Rendulic studies the infantry attack as described in English, French, Austrian and German manuals. Austrian manuals consider the infantry attack under the headings: Approach Marches, Gradual and Progressive Deployment into Attack Formation, Working Up to the Position of Assault, Organization of Assault, Assault, Penetration,

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Break Through, and Pursuit. German manuals follow the same course, but French and English (particularly French) stress the *prise de contact* in which German and Austrian training is deficient, and by considering the defence lacking in elasticity and depth, make no provision for gradually feeling the way against opposition to the final position of defence. English methods are criticised as keeping too definite a control of deployment in the hands of the battalion commander. The organization, strength and armament of platoons and smaller units are compared.

Cyclist Battalion tactics are discussed by Major Raus—the Battalion includes 9 mechanists and 7 motor-cyclists ; cycles can be connected in fours, each four pushed by one man, or coupled, each couple being ridden forward by one man—three-ton lorries of the battalion can take 25 cycles without special arrangement, and 50 or 100 if special attachments of different kinds are added for the purpose.

In normal march formation (single file) the battalion takes 5,000 yards of road. Advance Guard is, say, 1 mile in advance, but flank guards are almost always impossible from lack of parallel roads. A flank attack on a battalion is not, however, to be feared, because of the possibility of encircling counter-attack by the Cyclists.

In the attack attention is to be directed mainly to flanking movements in order to get full benefit of mobility.

In considering employment with other arms such duties as the watching of an exposed frontier or of a river with mixed detachments, *point d'appui* for reconnoitring cavalry, escort to artillery, and to engineers engaged in demolitions, are mentioned. In all cases cycles are taken as far forward as possible.

An article on the infantry gun describes a model produced by the Skoda A.G. works in Pilsen in 1918 (after trials in the field). Calibre 3·2 in., projectile 14 lb. The total weight is between 7 and 8 cwt., and is divided into 4 pack or 11 man loads. Designed principally for ranges under 2,000 yards, the max. range is 3,000, and high-angle fire is possible at very short ranges.

Direct fire is, of course, possible at all ranges, but the general design is that of a howitzer and its suitability for anti-tank work would seem to be questionable.

An article by Krüger on German tanks gives details of the A.7-V and L.K. I and II tanks which were actually used, as well as a few facts about the U and K models which never reached a practical stage. Tactical matters are discussed in the next number.

H.St.J.L.W.

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*HEERESTECHNIK.*

(*January, February and March*, 1924.)

A SERIAL article on the development of the German 16 field gun and light howitzer models is continued and finished in the January and February numbers. The technical difficulties and their partial solutions are described in the January number.

In summing up, the author refers to the tactical lessons which led to the demand for greater range, even combined with greater weight.

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Scientific " location " makes it necessary to keep guns further back for safety, and, on the other hand, presents well-fixed targets at greater ranges. Modern artillery leading, by concentrating fire from widely distributed batteries, also increases range. F.K. 16 and L.F.H. 16 were designed to give this greater range, whilst the gun did not exceed 27 cwt. and the howitzer 29 cwt. Although considerable criticism has been focussed on the design, it remains the best in actual practice, superior to the French 75 and to the recent Austrian model. But, good as the designs are, there remain many points for improvement, and even so the pre-war task of the artillery cannot be carried out by guns and howitzers of such weight. Close support of infantry demands the infantry gun, and the field gun becomes intermediate between the " infantry " and the " heavy " types.

Major Klingbeil's articles on " Peace and War Experience " in concrete construction of permanent and semi-permanent fortifications are devoted to foundations and to the characteristics of various surfaces and subsoils. The one point of interest is his statement that reinforced concrete platforms are always used as foundations for German permanent fortification.

Dr. Ing. Becker has an interesting series (February, March, *et seq.*) on the daylight photography of projectiles. After a short historical summary (dealing mainly with electrically-controlled instantaneous photography of the path of a bullet, by Cranz) he describes the cinematograph work of Major Duda, in Austria, and the " Ballistograph " which he has perfected. The ballistograph has four rigidly-connected objectives which are placed in a line parallel to the path of the projectile.

The plate is made to fall at a rate which gives successive exposures (1/10,000 of a second) (in strip form) opposite each objective. Exposure is made through a cylinder (placed behind the objectives). The cylinder has holes in it of a shape, and so successively placed, as to allow exposure through each objective in turn. As it rotates this cylinder makes per revolution a contact which actuates a photographic timing device. The probable error of measurement of velocity from the resulting photographs of the projectile is estimated as less than 0·2 mm. The description is very clearly given and well illustrated.

Dep. Ing. Stumpf begins an article on open girder iron bridges. The necessity for some standard pattern of railway bridge for spans up to 100 metres was first apparent in bridging the Save near Belgrad in 1915. Pre-war military types were for spans not exceeding 60 metres, and not up to modern weights. The " K " type, simple in theory and convenient in construction, was then evolved and is here described and illustrated by diagrams.

General Giessler retired from the active list early in the year. He was head of the inspection department which dealt with guns, small arms, engineering stores, mechanical transport, signal stores, balloons, etc., and some interesting details as to the working of this new department are given in a farewell notice of his activities, in the January number.

In the May, 1923, number of the *Revue d'Infanterie* Capt. Desaivre discussed the question of the calibre of rifles and machine-guns. He

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came to the conclusion that the tasks to be faced could not be solved by one universal calibre and advocates no less than three—0·24, 0·36 and 0·5 of an inch—covering zones from point blank to 6,000 metres—and engaging tanks and aircraft. This article is given a lengthy review. The German standpoint is then discussed and it is claimed that two calibres will, probably, serve the purpose by a judicious use of heavy and light bullets ("S" type).

Capt. Meyer Becherer writes of the lessons learnt by entente countries in mechanicalized artillery. Germany, not being allowed to experiment for herself, has to keep an eye on the foreign progress. The Americans have, he considers, gone further than European conditions and roads warrant. The most interesting and important development is the combination of wheel and caterpillar, to which final aim all seem to be tending. Artillery "portée," confined, for the most part, to the roads, and dependent upon borrowed teams for movement across country, nevertheless possesses a considerable strategical value. Weights and calibres will probably increase in proportion as mechanical transport is introduced.

An article by Th. Vahlen (in the February number) on the theory and practical experience of disturbing factors (meteorological) to the trajectory of shells and bullets may be of interest to the expert.

Two books of possible interest are reviewed:—

(*a*) *Die Fernrohre and Entfernungsmesser* (Telescopes and Range-finders), by Doctor A. König.

(*b*) *Explosivstoffe*, by Prof. Dr. Brunswig.

H.St.J.L.W.

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*THE MILITARY ENGINEER.*

*March–April.*

*Camouflage in the Russian Army.*—Colonel Kolossovsky, of the Russian General Staff, describes the principles and means of camouflage adopted in the Russian Army.

The subject is evidently receiving considerable attention. A special camouflage school has been established in Moscow and every division includes a camouflage unit.

*Chemical Warfare and the Engineers.*—Brig.-General Frier, Chief of Chemical War Service, surveys the work of his Service.

In peace, in addition to its military experimental and development work, it undertakes chemical research in connection with problems of civil and general engineering. The action of marine pests on timber piles is occupying its attention at the moment.

In war, the Service can best help the Engineers by covering bridging operations with smoke. A recent development is the method of sprinkling smoke from an aeroplane. The liquid, carbon tetra-chloride, is loaded in tanks and released under pressure at the speed of the aeroplane but in the opposite direction. It thus falls practically vertically and is said to produce very accurate and satisfactory results.

R.I.M.

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## *VOINA I MIR.*

(*No. 9 continued.*)

Captain Ritter contributes an article on the German advance in France in March, 1918, in which he traces the failure of the German attack to the changes made in the original plan of operations. Quoting a phrase from Ludendorff's *Reminiscences*, " Tactical considerations had to take precedence of pure strategy," he states that the exploitation of unexpected tactical success, involving change in the original plan, is allowable in the case of divisions or even Corps, but during operations on a large scale such as those in March, 1918, the original plan of operations must be steadily adhered to. In the attack called by the German Staff, " Michael," the original plan, which was briefly to drive the English into the sea by an advance of the 17th and 2nd Armies, with the 18th protecting the left flank of the 2nd, was, as a result of unexpected successes, considerably expanded. The tasks of the 2nd and 18th Armies were much increased. The latter Army was reinforced at the expense of the 17th, and the attack devolved into a simultaneous advance against the French as well as the English, an operation calling for much larger forces than the German Staff had at its disposition.

Lieut.-General Borisov, in an article entitled, " The Versailles Treaty and the Strategical Situation arising from it," enumerates the conditions which affect the strategical situation of a country, such as the outline of the frontiers, geographical position with regard to other countries, material resources. He then quotes from the Italian paper, *La Preparazione*, the military and naval resources of the great powers before 1914, and briefly describes what the general strategic situation in central Europe was at that time (to facilitate an understanding of post-war strategical conditions). He records the errors made by the German Staff in their appreciation of the strategical situation. He then discusses the various articles of the Versailles treaty, dividing them into " effective " and " moral," the former being Articles 5, 6 and 7 (dealing with the creation of new states, surrender of German colonies and surrender of arms). He considers the abolition of Austria-Hungary, containing 38 million inhabitants, and the formation of four smaller states, as the most important factor in the present changed strategical situation and refers apprehensively to the position of any one of the seven smaller nations, Austria, Hungary, Czecho-Slovakia, Poland, Serbia, Rumania and Bulgaria, in face of an " awakened " Germany. He considers Articles 7 and 9, dealing with the limitation of armaments, whereby 70 million people are deprived of the means of self-defence, as an insult to national feeling, and as unlikely to be effectual in face of provocation. Comparing the populations of probable groups of nations to-day, there are on one side, France, Poland, Rumania and Belgium, with 91 millions, and on the other Russia, Turkey, Bulgaria, with 150 millions, to which must probably be added Germany, Austria and Hungary, with 75 millions. The position of Czecho-Slovakia and Serbia in a future conflict is doubtful. Of modern frontiers in Central Europe 70 per cent. are between hostile and doubtful countries.

Such is the " firm " political situation created by Versailles.

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In "The Tactical Use of Gas" Colonel Kolossovski states that the fundamental principles of chemical warfare are the same as those for warfare by other methods, viz.:—

(1) The necessity for superior strength at the decisive point and moment,

(2) Decisive success can never be attained without active effort.

There are three types of gases, namely those producing (*a*) prolonged action, (*b*) short action, (*c*) penetrative action.

Shells filled with gas of the above types were called by the Germans "yellow-cross," "green-cross" and "blue-cross" respectively. The effect of blue-cross shells was increased by the fact that they burst into splinters, producing the modified effect of common shell.

Principles for the use of gas under different circumstances can be deduced from the experience of the late war.

In the preparation of an attack yellow-cross shells (mustard gas) must be used on distant points of enemy concentration, lines of communication, villages, headquarters, etc., but can only be used on nearer areas over which no immediate advance is contemplated. In warm weather the shelling should begin the day before, but in cold weather 5 to 7 days before the attack. When the objective consists of woods or copses, times must be increased by 1 or 2 days, as these retain the gas longer than open country. Owing to the perfecting of anti-gas apparatus in future wars the intervals will probably have to be increased. It was observed that mustard gas affects the soil over an area of radius 2 to 3 feet from the crater. The foregoing remarks refer to position warfare; there is no experience to show how such gas should be used in open warfare, but it will probably be to form screens on areas over which no advance is to be made.

The use of shells filled with "short action" gas will be confined to points where bodies of the enemy are likely to concentrate, such as forests, villages, cross roads, battery positions, etc. The Germans used a mixture of green and blue-cross with considerable success against battery positions. Shelling should be begun shortly before the attack —to start long before entails a large expenditure of shells and discloses the intentions to the enemy. In the late war the practice was at first to start shelling 1 to 2 days before the attack, but towards the end of the war this time was reduced to a few hours. When once begun, the shelling should be repeated every three or four hours.

An example of a correct and successful gas preparation is afforded by the action of the Germans from March 9th to 19th, 1918, on the eve of their great advance on the line Arras–La Fère against the 3rd and 5th British Armies. A sketch is given showing the distribution and intensity of gas shells on this front. Yellow-cross shells (prolonged-action) were used on those areas where immediate advance was not contemplated, namely, Liéven–Arras and Inchy–Gouzeaucourt, especially the latter, which formed a pronounced salient, from which flanking fire could be brought or counter-attacks made. The effect was striking, as the British Corps occupying this area (left flank Corps of the 5th Army) lost 5,000 men before the attack, and its confusion and demoralization

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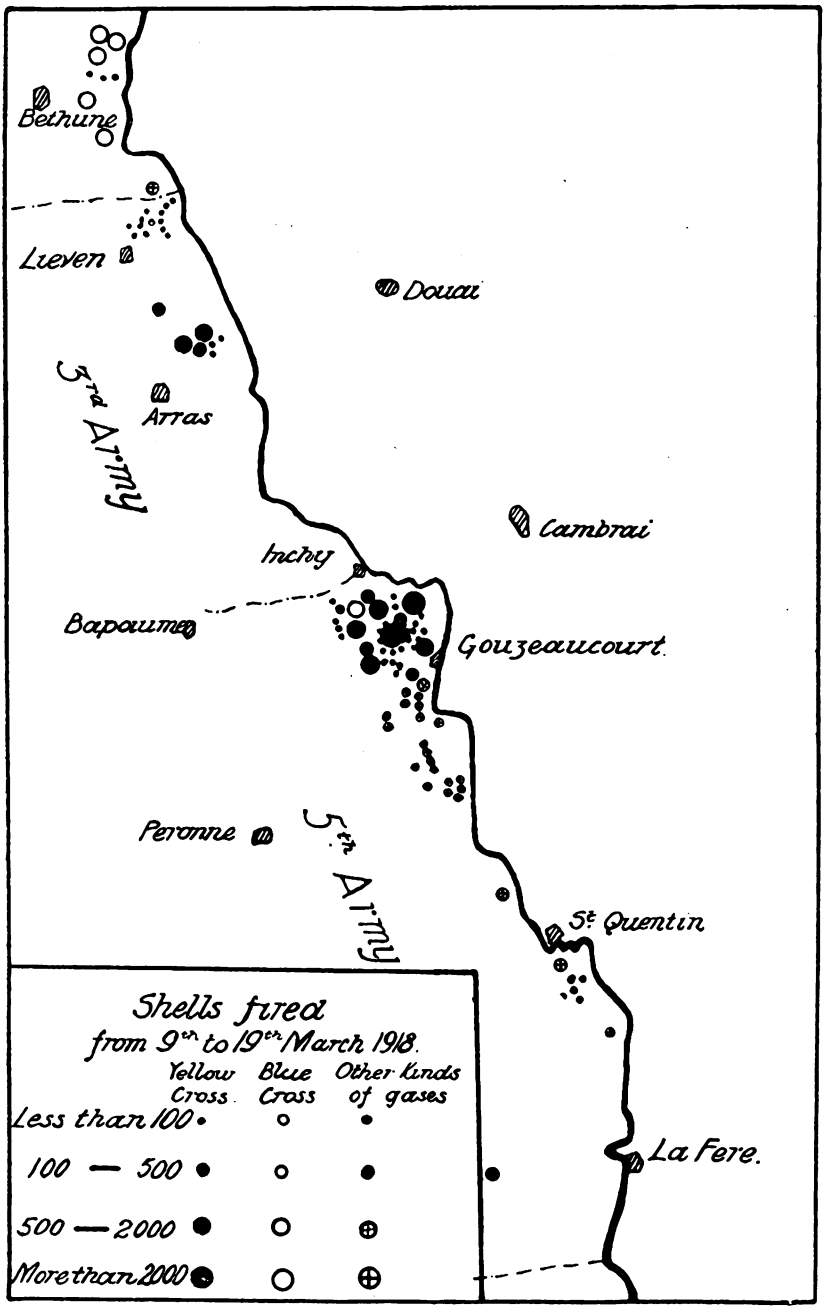
led to the defeat of the whole 5th Army. At the same time green-cross shells (short-action) were freely used in the chief area of attack, Gouzeaucourt–St. Quentin, thanks to which the British front was broken without much difficulty. Gas shelling on other portions of the front was in the nature of a demonstration. On the line Arras–Inchy, where there was no

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gas preparation, the 3rd British Army met the Germans with much greater success.

Another example of the successful use of gas was in the battle of September 26th, 1918, in the east of the Argonne forest, when the first American Army used mustard gas to protect its flanks. Fire began at night, six hours before the attack, and the results were highly successful.

During the period of an attack " short-action " gas shells can be used with advantage against places of concentration, batteries, reserves, observation posts, etc., timing being arranged so that the effect of the gas will have worn off before the approach of the attacking troops. " Prolonged-action " gas should be employed against objects on the flanks of the attack and on enemy flanking batteries, afterwards against distant points of concentration, railway stations, ammunition dumps, etc. During the attack, objects of immediate danger must be kept under continuous fire as far as possible and if much destruction is not effected the enemy will in any case be embarrassed by having to use gas masks.

In intervals between attacks, whilst localities are being fortified, " prolonged-action " gas is the most useful to protect the construction of positions and the organization of a new advance. It is particularly useful against counter-attacks and to stop concentrations of enemy troops in the rear. Important rear points such as stations, crossings, dumps, must be kept under a constant fire.

In defence and retreat " prolonged-action " gas must be used to an unlimited extent for the making of screens, blocking of lines of communication and bombardment of masses of troops. On retiring from a position the explosion of shells and grenades of mustard and other prolonged action gases inside deserted trenches, hollows, defiles, forests, etc., has great effect.

There is a wide future for the use of gas in war and the " detailed and persistent elaboration of methods for the tactical use of gas constitutes one of the most important problems for the consideration of every country desiring to omit nothing which might secure victory in future conflicts."

This number contains a review of the *R.E. Journal* of March, 1923.

(No. 10)

The tenth number opens with an article on " Strategical Defence " by Capt. Ritter. He states that a defensive attitude can be adopted by a country for several reasons, the commonest being to delay the enemy with a part of its forces whilst the greater part is concentrating and preparing for action. One aspect is shown by the withdrawal of the defending forces into the depth of their country, making use of its natural disadvantages to weaken the strength of the invaders. Another form consists of quiet observation of the initial movements of the attack by the defenders who, watching for mistakes and weak points, are ready to take advantage of them with concentrated forces.

The guiding principle of any strategic defence is the endeavour to compensate for inequality in strength by economical distribution and slow expenditure at a time when the enemy has to expend rapidly. This aim is favoured by the fact that in defence the element of movement plays a smaller part than in the attack.

Factors in favour of the defence are time, the advantages gained

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by the occupation of prepared positions, the use of home railways, the assistance of existing fortresses and fortifications, finally, the attacker will be operating in a hostile country and will not have the advantage of local assistance and institutions.

The defender, possessing greater freedom, for the above reasons is in a position to confront the enemy with an unsuspected situation by suddenly changing his line of defence, provided the theatre of operations is sufficiently large compared to the opposing armies. Such action on the part of the defence compels a change of plan on the part of the attack entailing many complications, such as a rapid revisal ofhis transport system.

A force advancing into a country with badly developed communications will be obliged to move on a wider front, exposing itself to the risk of being beaten in detail by an unexpected advance of the enemy. Napoleon, in February, 1814, gave a brilliant example of such action, and Frederick William, in the Seven Years' War, carried out his successful defence in a similar manner on a large scale.

Any attempt on the part of the invading force to pass by an important position occupied by the defence can always be paralysed by flank attacks; so acted the allied armies at Lützen in 1813, and General von Werder when opposed to General Buorbaki in 1871 at Villersexel.

Readiness for action superior to the opponent's is one of the most important conditions for strategical advance; it depends on quickness of mobilization, on the possession of sufficient armament and means of transport and on the suitability of the country's geographical position. The country which adopts an attitude of strategic defence can afford to spend more time on initial preparations. From the political standpoint the sympathies of other nations are more generally given to the attacked than to the attacker, a fact which may affect the situation in a considerable degree.

The defensive attitude, however, has serious disadvantages, for inherent in it is a confession of weakness. By defence alone a decision can never be gained, and the most that can be hoped for is a more or less honourable peace—such as Frederick the Great obtained. In the Russo-Turkish War defence led to defeat.

The defence can never be secure from danger to its communications and may have to evacuate favourable positions in order to safeguard its rear, as happened in the case of the 1st and 7th German Armies after their long and successful defence of the Hunding-Brunhild position.

Finally, the long sojourn of an army in one place favours the spread of infectious diseases.

A.H.B.

## *CORRESPONDENCE.*

### TIDES.

MAJOR-GENERAL A. C. JOLY DE LOTBINIÈRE, C.B., C.S.I., C.I.E., in forwarding the following letter for publication, explains that to him it proposes a new theory and one difficult to refute. He would be glad to receive criticisms upon it from any of those of our readers who are interested in the subject.—(ED. *R.E.J.*)

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DEAR GENERAL LOTBINIÈRE,

You once asked me, how did I account for the tides. I now intend to reply. My theory of the constitution of things has, as you are, no doubt, aware, rendered a gravitational field of force as a plenum of energy; hence I cannot look to attraction as an explanation of the tides. Indeed, it is worth while to point out to you that, even if physicists may be permitted to assume that mass generates a gravitational field of force, no explanation is forthcoming as to how such a developed field of force intersecting another field of force produces movement of the one mass towards the other. We can leave out the act of repulsion of two intersecting electrical fields of the same kind.

As long as force cannot be conceived as occupying space, a field of force has no meaning. A field is space: Hence arises the question—What contents of any space determine whether such is a field of force or not?

The term, "a field of force," really takes the place of the now disused term "action-at-a-distance," which only latterly became repugnant to men of science; though we still read that such men as Lodge and Rutherford continue speaking of attraction and repulsion.

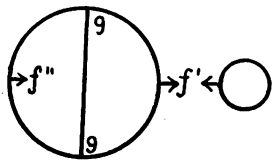
Be not, therefore, misled in believing that a field of force really gets rid of action-at-a-distance.

Now, since energy can be conceived as occupying space—for note how all its forms are fast becoming inertial; except that treacherous "heat"—it becomes easier to believe that these so-called fields of force are plena of energy. And this means that in a gravitational field the units of energy, as it were, push towards the centre of the mass.

It is easily understandable that under such conditions the motion of two masses towards each other can only be attributed to a diminution in intensity of the passages of the units of energy (gravity) between the two masses as against the intensity at the antipodes of that system —the earth and moon.

But that will not raise the water on both sides of the earth to produce those well-known antipodal tides: the theoretical explanation of which is confusing.

For imagine the earth covered with water to a uniform depth. It stands to reason that, on introducing the moon, the force of attraction in a line joining the centres of the earth and moon must be always greater than the force of attraction of the earth at right angles to that line; that is, both $f'$ and $f''$ individually must be always greater than $g$.




This means that the water at $f''$ must be lower than that at $g$, and the water at $f'$ must be higher than that at $g$.

Where do the antipodal tides come in in this construction?

Then, considering there is no pendulum that can record side displacement by the moon, it is futile to argue that the water at $g$ is made lower than at $f''$ by side-attraction or slipping towards the moon.

The revolution of the earth will not help matters at all in respect of antipodal tides.

I have often wondered why no compensation is made in pendulum-swinging in respect of the positions of the moon and sun.

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The conclusion I have come to is that the main cause of the generation of tides is distortion of the earth. That is, a wave of strain is constantly perambulating the earth. For it seems highly probable that a mass of this sort rotating on an axis cannot be perfectly rigid. Thus, as it were, the diameter of the earth, measured through the equator of revolution, is not constant: which inconstancy constitutes a wave.

In this way tides are a mechanical effect and not developed astronomically.

You will do me a favour in replying.

Yours sincerely,

Coromandal P.O. Mysore State. LOUIS STROMEYR.
*7th April*, 1924.

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## TIDAL ELECTRIC POWER SCHEMES.

To the Editor, *R.E. Journal.*

SIR,

At the end of his interesting article in the December *R.E. Journal*, on the construction of dams in the tidal creeks near Shoeburyness, Major Kirke puts forward a suggestion made to him by a visitor for the utilization of the tides to generate electricity. Countless schemes for doing this have been proposed in the past, and abandoned, usually because the promoters have overlooked certain fundamental facts which govern the economics of all hydro-electric schemes, tidal or otherwise.

In any such scheme the output of power varies roughly as the product of the volume of water passing through the turbines multiplied by the head. But the cost of installation varies roughly as the volume of water dealt with. It therefore follows that the cost of installation *per horse-power* varies more or less inversely as the head utilized. Owing to the relatively large sum required as interest on the capital expended on a low-head installation, such installations are rarely a financial success, particularly if other competitive sources of power exist to limit the price charged per unit. On this ground alone a scheme such as the one proposed to Major Kirke would almost certainly prove a failure from the financial point of view.

In this case, however, a further practical difficulty lies in the large amount of sand and silt carried in suspension by the water. The reservoirs would, as already experienced at one of Major Kirke's dams, gradually silt up, thereby reducing the available volume of water and head. Unless special steps were taken to prevent it, such water would also soon play havoc with many types of turbine, for if the water carries *any* sand in suspension it soon wears out the working parts of the turbines, and causes excessive charges for maintenance and renewals.

The second of these difficulties can be to a large extent overcome, but an economically satisfactory solution of the old and fascinating problem of the utilization of tidal power has yet to be found.

Yours faithfully,

LAHORE, INDIA. E. P. ANDERSON, *Major, R.E.*
*24th March*, 1924.

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# *THE HUTTING PROBLEM IN THE WAR.*

*By* THE LATE MAJOR-GENERAL SIR GEORGE SCOTT-MONCRIEFF, K.C.B., K.C.M.G., C.I.E.

## I.

DURING the war, as we all know, the peaceful countryside was invaded and disfigured by groups of unlovely huts, mostly of brown boards and black roofs, assembled either in clusters of a few, perhaps guarding some railway bridge or junction, or in far-spreading lines for thousands of men under training. Now, for the most part, these have disappeared, and the countryside has resumed the charm of rustic beauty which had been so rudely disturbed. Before the remembrance of the episode has passed away it may be interesting to record what was done, for the story is one of some interest.

## II.

At the outbreak of war, the Works Branch of the Army had practically nothing to do, other than endeavouring to prepare preliminaries for possible eventualities. Operations in the field, so inseparably connected with military engineering, had not developed, and all requirements for home defence had already been considered.

But when Lord Kitchener's appeal for 100,000 men was made to the nation, it was evident that the New Army would require to be housed as well as fed, clothed and armed. There was actually enough barrack accommodation in the country, but much of it was in isolated garrisons, and it was a matter of primary necessity that the new troops should be quartered in brigades and divisions with ground suitable for training. By adding to existing training centres, such as Aldershot, Salisbury Plain, the Curragh, etc., a good deal could be done, but, withal, one division at least would have to be hutted in some new place, and many new hutments would have to be built to supplement the existing needs at the training grounds already existing. Moreover, three or four large remount depôts, each for 1,000 horses, with their attendant grooms, etc., were needed near the ports of Southampton, Bristol and Liverpool (these were subsequently largely increased), and at nearly all the principal defended ports on the South and East Coasts of Great Britain huts for coast defence troops were required. The order of urgency,

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however, was for the New Army first of all, and upon that enterprise all attention had to be concentrated. The order for construction of hutted camps was issued on the 12th August, 1914, and by the 14th complete working drawings for a typical hutted camp of a battalion of infantry at war strength, including 17 different designs (*i.e.*, men's huts, recreation rooms, lavatories, cooking huts, officers' quarters and mess, sergeants' mess, etc., etc.) were complete and received the sanction of the Army Council.

This rapid result, achieved by the energy and skill of Major B. H. O. Armstrong, R.E., and his chief assistant, Mr. J. D. Michel, and their small staff of draughtsmen working day and night, was remarkable. For it not only involved the completion, in every detail, of a large number of plans, but it meant the settlement of several very important sanitary and administrative problems, such as the provision of baths, the supply of water, the nature and amount of artificial light, and of interior space and ventilation, the arrangements for messing and cooking, and many other such matters. Indeed, so thoroughly was this done that the result was considered by Lord Kitchener to be unnecessarily good, and after the first camps were far advanced he gave orders to curtail a good deal of what he thought was unwarrantable luxury, in the shape of dining-rooms and drying-rooms, etc. Baths, however, were admitted to be a necessity always, both in this country and in the field, and this in itself was a matter of great sanitary importance and a new departure in military administration.

## III.

A rapid result such as this preparation of the typical plans did not mature all at once. It was the outcome of long and careful consideration and of some experience. It may not be out of place here briefly to record what that experience was and how it had been considered in the preparation of the typical plans. During the South African War some additions to our existing training centres, especially for the increase of artillery in modern armies, had to be constructed. To avoid the expense and delay involved in the construction of permanent barracks, these additions were of a hut type, chiefly corrugated iron buildings, lined with wood. But it must be admitted that, though they were less costly than the type of permanent barracks then in vogue, they were in many respects very unsatisfactory, the saving in money being more than counterbalanced by the cost of maintenance and the general discomfort involved. The attention, therefore, of the War Office technical staff was directed to the possibility of so utilizing modern methods of engineering that a simple, inexpensive, and rapidly constructed type of building should be devised, of a reasonably comfortable nature, and yet free from one of the great objections to permanent barracks, namely,

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the great expense involved in alterations, or " re-appropriation," as it is officially termed, when, owing to exigencies of military service or the advance of sanitary science, buildings originally intended for one purpose have to be altered to suit some totally different requirement. From these considerations was evolved a type of steel and concrete construction which cost far less than the permanent and substantial buildings normally adopted, and the consideration of this type, involving, as it did, constant consultation with the Army Medical authorities and the Quartermaster-General's department, prepared the way for even more rapid and less substantial forms of habitation, to be adopted when the need arose.

On two occasions between the South African War and 1914 the need for such did arise, illustrating how the experience of peace does help in solving one of the problems of war.

## IV.

The first occasion was in 1907, when, on the 14th January, an earthquake at Kingston, Jamaica, destroyed in a few seconds all the buildings in that town, and overthrew the substantial fortifications on the other side of its famous harbour at Port Royal. A telegram to the War Office asked that, at the very earliest possible date, a complete hospital for 80 beds should be prepared and sent to the colony. It is, perhaps, hardly necessary to say that a hospital for a given number of beds means a great deal more than the mere wards for sheltering that number of sick. The accessory buildings, the administration block, the rooms for medical stores, operating rooms, quarters for medical staff, nurses, etc., are often a more extensive problem than the actual wards. In this case, owing to the lack of labour in the colony and its occupation with other work, it was necessary to send with the hospital huts a sufficient number of skilled workmen to carry out the erection. So a company of Sappers was warned to be ready for embarkation, the officers in charge being instructed to watch the progress of the preparation at home so as to be ready to carry out the work with all speed on arrival. Meantime, some of the best experts in the London building trade prepared the huts from designs generally prepared by the War Office staff, and, by the beginning of April, less than three months after the earthquake, *the hospital was in actual use* in Jamaica, where the material had been all landed complete about a month previously. Later on, when the barracks, of steel and concrete, on earthquake-proof principles, had been rapidly erected, the medical authorities were asked whether they wished a new and more permanent hospital. Their answer, however, was that the hospital, which they had thus hastily received, was all that was required.

The second of the two instances occurred in 1912 in the building

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of the Flying School at Upavon on Salisbury Plain. In January of that year a site was selected by the Committee, of which Colonel Seely, M.P., was president, and which was then considering the formation of the Royal Flying Corps. This Committee selected the site for the school solely on aviation grounds, naturally. From an engineering point of view it had no advantages. It was far from any railway delivery, it had no water supply, still less had it any electric power. Materials for construction had all to be brought to the site. The buildings were of an unusual nature, for aeroplane sheds involve gigantic doors, and abnormal roofs. Large workshops, to admit full-sized aeroplanes, and much shafting, belting and miscellaneous tools, had to be thought out. Meteorological stations had to be provided, and these and many other requirements were still in the uncertain stage which always is inseparable from a new and gradually developing art, so that complete design and estimate of requirements was at first impossible. Even the number of officers was uncertain, so that their quarters and mess could only be tentatively built. With all these limitations, however, the work went on rapidly, was completed in six months, and the first class of instruction was started in August, 1912. We know now how vitally important even one month was at that stage of aerial warfare, and it is not pleasant to think of what might have happened if the construction of this school had followed the "leisurely trundle" of building operations normal in this country.

## V.

Thus it happened that when Major Armstrong (to whom more than anyone the credit of the Flying School is due) got the word to produce hut designs in August, 1914, he did not lose a moment. Later on he produced the well-known "Armstrong hut" which, constructed in sections, was made in workshops and sent out ready-made to any proposed site and rapidly erected. But, at first there was no necessity for this, and, indeed, there was considerable advantage in utilizing local materials and labour. The huts were at first built of a wooden framework with corrugated iron on roofs and external sides, and with asbestos lining inside. This was the quickest and probably best form for a limited number of huts, and if only the first 100,000 men had been all that needed accommodation, no other sort would have been necessary. When, however, the numbers rose by hundreds of thousands, until the demands amounted to about a million, some other material was required. This point, however, will be considered later.

The reason why a type plan of a battalion hutment was so important is that it furnished a guide to any class of unit. The 17 plans which made up the whole typical set, could be used for any

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other unit. Thus, a brigade of artillery has a different strength in men and horses from a battalion of infantry, but the only difference involved was that more stables of the approved type, and fewer men's huts, were required, and the relative arrangement of the whole had to be somewhat altered. The same types of huts were used in all cases, and it is a tribute to Major Armstrong's foresight that practically the same types were used during the whole war, though details were frequently improved as a result of experience, and materials differed with local circumstances.

The hut for the rank and file, which may be said to be the nucleus of the whole, was a small one only, for 24 men and 1 N.C.O. The reason for not having a larger one was mainly on the ground of discipline, the underlying idea being that 24 entirely raw soldiers would be more easily ruled by 1 N.C.O. than a greater number, say 50 or 100. In addition to this, and also to the fact that a small building is more easily fitted to the irregularities of ground than a large one, there was always the possibility of re-appropriation; experience having shown that military policy is by no means a constant, and that a building designed for, say, a recreation room, may be required shortly as a barrack store, or divided up into officers' quarters. And finally, the risk of fire has to be remembered, and a small building is more easily isolated in event of a conflagration, and, of course, more easily evacuated, than a large one. For these reasons the huts were small, relatively. Our American allies were surprised at this. They had built their huts for 100 men in two floors. Possibly this may have been cheaper, possibly it was more convenient and it enabled a larger number of men to be housed to the acre than our plan did. But it is doubtful whether it was a better plan, for the reasons above given.

Major Armstrong also planned his type grouping so that down the centre of his battalion camp came the accessories, recreation room, dining-rooms, sergeants' mess, kitchens, officers' mess. On either side came groups of men's huts and of officers' huts. The underlying idea was that the former (accessory buildings) should be erected, complete, first, and that the men and officers should sleep in tents, with boarded floors. The winter was coming, the materials and labour problems were gigantic. It would be better to ensure warmth and comfort to the men in their dining-rooms, etc., until they actually had to sleep, rather than, by grasping at completeness, fail to give even a reasonable amount of warmth and shelter. As it was primarily a question of health, it was referred to the medical authorities, and the Army Council, after hearing their views, pronounced against the proposal, and ordered that every endeavour should be made to provide sleeping accommodation concurrently with the accessory arrangements, and not, as was intended at first, build the huts to replace the tents as, and when, circumstances

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admitted, afterwards. This was tried, but it proved an impossible task. Later experience proved that men might quite well have lived in tents all winter, provided they had warm shelter to occupy until night came on. It is feared that the attempt to give them more, proved to be a cause of intense discomfort for thousands during the winter of 1914–15.

VI.

Although the typical hut scheme was the same for all places, it is obvious that every place differed in respect of roads, drainage, water supply, and in most cases artificial lighting. These problems, which, in some cases, were of great difficulty, had to be solved in each case from the local conditions. It was decided that, wherever possible, local water supply and sewerage systems should be utilized, but, of course, in many cases this was impossible. If a local gas or electric light supply existed, it was also to be used, but if none was available, then an electric power station, with oil-engine, dynamos and accumulator, was to be built, and a scale of lighting for the various buildings was worked out. This subject was one that was not hastily decided, for there were many matters to be taken into account, and it was not finally settled until some weeks after the first plans were sanctioned. As regards sewage disposal, where no public facilities existed, it was decided that all liquid refuse should be treated in filter beds and thoroughly purified before discharge into some water course. Soak pits were not to be used in England, though in France afterwards they were largely in vogue. Solid refuse was burnt in incinerators, the best pattern of which, however, was not settled until after a good deal of experiment. In the case of large camps for, say, 10,000 men and more, it was found, later on, that a regular water-borne system of sewage was the most satisfactory. As the hutting programme developed, during the first 12 months of the war, these problems of water, electricity, and sewage became enormous, and it was found desirable to have at the headquarters of each military command a specialist in each of these engineering subjects, whose responsibility was limited to the proper working of his own branch of each of the foregoing. These gentlemen were usually civil engineers over military age, or who had returned wounded from the front.

VII.

Thus it will be understood that the hutting problem, as it presented itself to the War Office authorities in the early months of the war, was more an engineering than an architectural one. Complaints were freely made, from influential quarters, too, that, with the immense programme of hut building, no advantage was taken of the services of the many members of the architectural profession who were out of work. It will, however, be understood that the archi-

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tectural problem, *i.e.*, the designing of the actual buildings, was practically complete with the preparation of the type plans. That nothing more was wanted is proved by the fact that four of the large divisional camps at Clipstone (Notts), Puckridge (Staffs), Oswestry (Salop), and Rhyl (Flintshire) were entrusted to the Barrack Construction Directorate of the War Office (since abolished), whose permanent operations were at a standstill. This directorate, wholly under the control of professional architects, and with a free hand to accept or reject any designs prepared by another directorate, had handed over to it the whole of Major Armstrong's type plans. As the architects concerned did not make even a suggestion of alteration in design, it may be fairly concluded that, architecturally, there was nothing worth changing. But the engineering problems everywhere were varied and in some cases exceedingly difficult, and these were dealt with by the existing engineering staff in the commands, reinforced by capable retired engineer officers of wide experience, and by the specialists above mentioned.

## VIII.

One other point must be mentioned before leaving Major Armstrong's type plans. The cooking of regular meals for 1,000 men was a problem of no small importance, and for some years before the war the War Office staff concerned had been very carefully considering the question of the best sort of kitchen ranges and boilers. They had been in touch with caterers in civil life, such as Lyons & Co., and with manufacturers in various parts of England. The result was that the types of cooking ranges and of boilers formed the nucleus of the plans of kitchens, serjeants' mess and officers' mess kitchens, etc., and it is satisfactory to note that, in spite of the enormous demands which subsequently were made on these manufacturing firms in the first year of the war, the supply never failed, and in the many complaints which arose from time to time about various matters, no complaint ever came to notice about the nature or the efficacy, or the fuel economy, of the types selected in the first instance. This fact is very much to the credit both of the designer and of the manufacturer. Concurrently with the design of the kitchens was the design for dining-rooms and "wash-up" sculleries, and it is very much to be regretted that, in the interests of economy, Lord Kitchener ordered these to be curtailed as luxuries. Those hutted camps which were provided with them were far better off than those in which the men's dinners had to be conveyed, in some cases, considerable distances, to the sleeping huts.

The economy was, in any case, not very great, though it is not easy to say, categorically, how much was saved in actual cash.

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The estimated cost of a type battalion hutment for 1,000 men was £15,000, and at the time it was submitted to the Army Council, the anticipated increase in cost in, say, six months was at the rate of £5 per man extra. This £20 per man was estimated to cover all external and accessory services. As a matter of fact, the cost eventually worked out to about £22 or £23 on the average, and it included not only water supply, drainage, roads and railways, lighting and power, but rifle ranges and all training accessories and hospitals with their constructional requirements. But £15 per man, which was the first estimate, was considered too high, and the Secretary of State ordered every possible reduction, saying that all that was required was the roughest class of shelter as a substitute for tents. He was reminded that he had not soldiered in England during winter for many years, and that he must not think that the " wattle and daub " huts which he suggested, as a result of his Indian and Egyptian experience, would be either capable of resisting an English climate, or quickly erected. He agreed to this expedient being abandoned, but gave orders that, as far as possible, expense must be reduced by the curtailment of every luxury, and by utilizing the building talent of the troops wherever possible.

This last point was taken up in connection with some of the yeomanry and territorial troops on Home Defence duty, especially in Kent and Sussex. Some of these had professional men (architects, etc.) serving with them, who said they were quite prepared to house their units at a lump sum—£8 to £10—per man. They were given permission to do so, and copies of type plans were sent, though they had a free hand to deviate, if they liked, from the types. Some of the hutments thus built were excellent, others were very poor, and when the accessory problems came to be considered, the saving in cost was not worth mentioning. Much the same result followed the patriotic proposals of some of the great cities (Glasgow, Newcastle, Birmingham, etc.), whose municipal authorities not only raised and clothed, but housed, the splendid battalions of their citizens. These city fathers, shrewd business men, visited the War Office, were given all type plans and all collateral information, were told that £12 to £15 per man was the maximum that could be spent, and they built their huts accordingly. But they hardly ever did the work completely without asking for some additional funds. So that one may fairly say that, for the first six or eight months of the war, £15 per man was a good round number for the work required. At Aldershot work was done cheaper, but Aldershot is already supplied with water, drains and electricity, and its then Chief Engineer (General Gibbon) was a master of his craft.

It may be added that, after the war, many of the hutted camps were sold by the Disposals Board at figures considerably in excess of their original cost. It is believed that, all things considered, the

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country did not pay heavily for the housing accommodation built during the war.

## IX.

Major Armstrong's type designs, therefore, swiftly and surely solved the problems of *what* to build for the New Army, but there remained the equally important question of *where* to build, and *how* to get it done. As regards the first of these questions, additions could be ordered at training centres already existing. Aldershot had sites galore, so had Salisbury Plain, the Curragh, Shorncliffe and Colchester. Rainham rifle ranges, near Purfleet in Essex, could take a brigade, and perhaps something might be done at Tipperary or Buttevant. But still there was a division of the First Army "out in the cold." A small sub-committee, consisting of Lieut.-Colonel Pell (of that fine regiment, the Queen's West Surrey), fresh from the Staff College and imbued with latest ideas on military training, and Colonel Cowan, R.E., one of the finest rifle-shots in the Army and the greatest expert on rifle ranges in the country, were dispatched at the same time that Major Armstrong got the word to start on his plans. Cowan and Pell went to the headquarters of Commands to seek for information for available sites. Afterwards we learned (what, indeed, we might have guessed) that this was not the right quarter to seek information. The men who really knew about the country were the Masters of Hounds, and they would have been only too glad to help if they had been asked. However, they were not called in just then, and for a day or two the returns were blank. Then, providentially, a generous offer came from Earl Brownlow, putting his beautiful park at Belton, near Grantham, at War Office disposal. Cowan and Pell went there, were warmly and kindly received, and decided that it was excellent. So Grantham became the headquarters of the 11th Division of the Army, that ill-fated and gallant division which, later on, left so many of its gallant lads in the ravines and jungle of the Gallipoli Peninsula. Orders were given, in August, 1914, that accommodation was to be built for the 13 infantry battalions of the division. Later on, orders were given for the artillery and engineers also to be quartered there. Before the huts for these were finished, orders were given that more infantry, and no R.A. and R.E., were to be quartered there. So stables were converted into barracks and water-troughs into lavatories. Before this was finished, the whole was turned into a machine-gun school, with a huge number of officers under instruction, and a substantial following of Q.M.A.A.C. This involved more and very extensive transformation, and may serve as a useful commentary on the question of "re-appropriation," and the folly of building in too solid a manner.

Later on, the whole question of selection of sites was taken in hand

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by the Quartermaster-General alone. Pell went off to command a battalion of his regiment in France and was there killed in most heroic circumstances. Cowan continued to evolve rifle ranges in England and Scotland, also a few in France. Altogether, he constructed over 200 of them, and beyond the accidental demise of a cow in Essex, there was not a single accident or complaint on any of them.

Whether the sites subsequently selected were suitable from a training point of view, it is not the province of this article to say. From an engineering point of view, some of them left much to be desired.

The *how* to get the work done was the next problem. It was obvious that even with a moderate programme of hut building, the supply of the three principal materials, corrugated steel sheets (galvanized), timber and asbestos sheets, would be a very big proposition, and so a recommendation was made to the Contracts Branch of the War Office that all these three materials should be placed under Government control. The Director of Contracts agreed as regards the asbestos, he arranged for the forbidding of export of galvanized steel sheets, but he could not agree to commandeer in any way the national supplies of timber, and he did not apprehend shortage, for the Surrey Commercial Docks in London and the timber yards at Hull and other ports were full and import was going on cheerfully. The corrugated steel manufacturers were, however, much perturbed at the embargo on export of their stock, for their colonial trade is the chief basis of their business. They represented that, if only they were allowed to export to British colonies, they would supply the War Office demands at prices lower than those of the market. This was agreed to, and for a while everything went smoothly. Then, suddenly, galvanized sheets became unobtainable. The disagreeable fact came to light that practically the whole spelter, or zinc, trade of the world was under German control, and with the cessation of German overseas trade the supply ceased. This was a serious disadvantage to the hutting programme, for it meant that either the corrugated steel sheets now supplied would have to be painted or otherwise protected from weather (and whatever the process would be, it would involve extra time and labour, both being very precious), or else some other material would be needed for walls and roofs of huts. And no other material was or is so expeditious in every respect as galvanized iron.

The timber question was even more important. It is easy, after the event, to suggest remedies, but it seems clear that if the Director of Contracts had put the matter, on the grounds of patriotism, in the hands of a few leading experts of the timber trade, they would have made arrangements of the very best and most economical character. Private conversations with some of these indicated such a possibility.

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And in connection with this, a good deal of what is called in Shanghai "coffee-house pigeon" was effected; that is to say, information by men of influential position and knowledge given unofficially in clubs and railway carriages, etc., resulted in some valuable and advantageous purchases. But nothing officially was done until, some months later, the matter was put by the Treasury in the hands of a purchaser, paid at a percentage on his dealings. It may be remembered that this gave rise to much adverse criticism.

## X.

Apart from the material supply, there came the question of contracts or other means of executive work. There are four such methods. First, the work may be done by direct labour, the engineer being his own contractor, purchasing materials and employing labour directly without any contractor intervening. This system, if in the hands of a man born with a special genius for such work, may be most valuable. Such a man was to be found in the then Chief Engineer at Aldershot, whose work was at once economical, swift and excellent. He had the reputation of getting the last ounce of work out of every man under him, for which reason he was not beloved by the usual War Office contractors, nor, indeed, by the financial authorities, who were slow to understand how it was he managed to set at nought their cherished routine. The huts at Aldershot were far the best, and far the cheapest, of any built in the United Kingdom. But the personal and local circumstances which obtained there were unique, and could not be reproduced elsewhere.

The second method was to give out a contract where the work is measured after completion, and payment made according to an agreed schedule of prices. This, however, postulates agreement as to the said schedule and, as a basis of agreement, some fixed rates of labour and materials. Under war conditions anything like fixity of cost was out of the question, and the preparation of a schedule of prices impossible.

The third method was the one normally in vogue, and a sort of fetish among some people as the one and only way to get work done. Plans of all the proposed work having been prepared in full detail, a statement or schedule of the quantities of each class of work is prepared by quantity surveyors—a process normally entailing considerable labour and much time. When the schedule, thus elaborately prepared, is complete, lump-sum tenders for the whole work, based on the schedule of quantities, are invited from selected firms of contractors, and usually the lowest tender is accepted. This method, the normal one in peace, is probably the best and fairest, in times of settled industry when prices have become more or less

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stabilized. But the time spent on the preparatory work is very considerable, and, moreover, the accuracy of the whole depends largely on the completeness with which the engineer or architect has foreshadowed every requirement. It will be seen that in many respects this was seriously inapplicable to the work proposed in the hutted camps, where not only time was of vital consequence, but where the local conditions varied so much in respect of accessory requirements.

The fourth method was the system of actual cost plus percentage. Here the contractor undertakes to do the work for the actual cost in labour and materials, plus a percentage to reimburse himself. This is, of course, open to the obvious objection that the contractor has every inducement to spend money, and no personal reason for trying to be economical. But if, at the elbow of the contractor, there is a responsible engineer who has full power to say what shall be done, and what labour shall be employed, and if there is a departmental accountant who not only scrutinizes every bill as it becomes due, but also sanctions every order that is issued, this system is not only capable of being made most efficient and speedy, but it is the only one which gives satisfactory and economical results in a time of change and fluctuation. The element of competition can be introduced into it (and was so introduced at a later period of the war) with most satisfactory results. At the beginning of the war, however, very few officers at the War Office knew much about it, or had any experience of it. It was anathema to the Contracts Branch for the obvious reason that it was a negation of contract, ordinarily understood. Nevertheless, the system seemed to present obvious advantages over the third method above mentioned.

Just then, however, a contractor of wide fame, Sir John Jackson, wrote to Lord Kitchener and offered his services to carry out any works at cost price. This offer was most opportune. It was decided to ask Sir John to take up the construction of the camp at Belton Park for 13 battalions, at Purfleet for 4 battalions, and at Ormskirk, near Liverpool (offered generously by the Earl of Lathom), a remount depôt for 1,000 horses. It involved an expenditure of at least £300,000. Sir John Jackson agreed, and a conference was held on the 17th August between him and the officers of the War Office branches mainly concerned, to settle details. During the week that followed he was busy collecting materials and labour, and on the 23rd August—the fateful day when our troops first came into touch with the Germans at the battle of Mons—the work at Belton Park was actually begun.

The hutted camp there was ready for occupation in the first week in November, less than three months after the first sod was cut.

The events of the following week, with its tremendous issues, so far affected the programme of hutting that the attention of the

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officers of the engineering staff, like that of every other branch of the Army, had to be concentrated on other arrangements of a military character, which were of vital importance to our national safety. With these we are not here concerned, except that there was inevitably less grip of the building developments in some parts of England than ordinarily would have been the case, and certain arrangements as to hutting were made, in the Southern Command especially, which gave rise to a good deal of trouble later. For the raising of the Second Hundred Thousand, followed immediately by the Third and Fourth, meant a vast scheme of new hutted camps. Moreover, the colonial troops from Canada, Australia and New Zealand were announced as coming to the aid of the mother country. It was proposed to quarter these, at first, in Windsor Forest, where the proximity to the Sovereign would appeal to their sense of the bond of Imperial unity under the Crown; the forests of Windsor could be utilized (as they were, very successfully, later) by them in building their own huts, and the comparatively easy access to the site would enable materials to be sent to them without the chance of being held up on railways already congested and strained to the uttermost. But training questions were obviously paramount. Windsor had no troops with whom the Colonials could co-operate and prepare for battle. So the plan, with its obvious advantages, was abandoned, and Salisbury Plain, already a hive of military activity, was chosen instead. Sir John Jackson was again called upon to undertake the work. He was, however, by this time not the only contractor in the field. Early in August his example had been followed by others. A list had been prepared, at the request of the War Office, by the Secretary of the Institution of Civil Engineers, showing the firms most likely to be ready to undertake work on similar terms, and an officer from the Works Department visited them all and learned what they were prepared to do. Other firms applied direct to the War Office. There was thus no lack of willing and capable experts.

Sites for large hutted camps were being selected all over the country by the Quartermaster-General and, as soon as any one site was approved, immediate arrangements were made to start work. In some cases these sites were the gift of patriotic owners, like Earl Brownlow; in other cases they were public commons, with old-established privileges; in a few instances they were grounds taken up under the Defence of the Realm Act. Retired Engineer officers of experience offered their services as supervisors. Fortunately for the nation, some of these were men of great engineering experience and administrative capacity, not too old to be still active and energetic. Thus the great camp for 40,000 men at Catterick (of which more hereafter) was under the supervision of Colonel Exham, C.B., who had been the engineer of the great naval

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base at Rosyth ; at Ripon (also for 40,000) the superintendent was Colonel Ellis, C.B., a former Chief Engineer of the Bengal Command. Another Indian officer, Colonel Finnis, C.S.I., was at Brocton, Cannock Chase ; while Brig.-Genl. Buston, C.B., D.S.O., a former Chief Engineer at Aldershot, supervised the work at Prees Heath in Shropshire. What the country owes to these and other capable men cannot be estimated.

But the materials difficulty was by this time very acute. The rapid construction which was possible at Belton Park, where timber and galvanized iron sheets were easily obtainable, was not possible with timber becoming every day scarcer, and galvanized iron wholly unprocurable. The very rapid construction of the Belton Park Camp gave a false hope to the authorities, anxious, as they naturally were, for the hutting to be accomplished before winter set in. The weather, too, which in September was fine, broke about the middle of October, and resulted in one of the wettest winters on record.

## XI.

Meantime hospital requirements had to be faced. Major Armstrong's activities, released to a great extent from the accommodation question, had now to be turned to the design of hutted hospitals, for 600 beds and lesser numbers. By the middle of October the type plans were finished, with the co-operation and sanction of the medical authorities.

The nucleus of hospital design is the ward, and Major Armstrong's ward was for 25 beds, *i.e.*, 24 ordinary cases and one special case. Later on, in France, this design was modified by the omission of the one special case. There was a nurse's duty room and store, and, separated by a clear passage, there were the bathrooms, lavatories and other similar apartments. Wards were connected by covered-in passages, which also communicated with the administrative block in some cases, and with the operating room. The administrative block provided the necessary office accommodation, the waiting-rooms, reception-room, dispensary, etc. There was a separate block for nurses' quarters, and another set of huts for medical officers with their mess rooms, and for the rank and file of the R.A.M.C.

The wards were usually parallel to each other and placed so as to obtain air and sunlight. In some cases in France the wards were placed all round the operating rooms (for these, in the field, had to be on a larger scale than in England), and in the huge hospitals at such places as Le Treport, Etaples, Rouen, etc., the details were somewhat different generally from the type plans. Where private hospitals were designed by such organizations as the Red Cross, St. John of Jerusalem, etc., there were often special features, but, broadly speaking, the arrangements followed the same lines as above indi-

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cated. Later in the war, Major Armstrong devised a ward block for 100 beds, with four beds instead of two in each unit of length. This ward had two rows of pillars at intervals longitudinally, the roof in the centre being higher than at the sides. At the place where the roof changed level there were rows of windows above the level of the lower roof. These, opened by cords from below, gave light and ventilation, in addition to that furnished by the side windows. This type of hospital, however, did not come into being until the war had progressed for some time, and the tale of wounded risen far above the early anticipations.

The interior of the wards was lined with asbestos plaster of a special kind, smooth and bright, generally tinted with some restful colour. The effect in the appearance of the wards, especially when these were brightened with flowers and the tasteful care of the nursing sisters, was charming, and would compare favourably with any hospitals in the land. Yet the cost of these hutted hospitals was not great, only some £80 per bed, and it is probable that for practical purposes they were as efficient as the permanent " palaces of pain " which, in civil life (before the war), cost as much, in some cases, as £1,000 per bed. It may be added, also, that such temporary buildings as the ones built in the war lend themselves to alteration, in consequence of the growing demands of sanitary and surgical science, more easily than those of a more substantial character. Yet it must in fairness be added that most civil hospitals, especially in great cities, must necessarily be of an imposing architectural character, and must conform to local building conditions—factors which were, of course, absent in war hospitals.

As a rule, the hutted hospitals in Great Britain were built as an integral part of the large hutted camps and were rarely for more than 600 beds. There were a few isolated exceptions, such as that for Indian troops in the New Forest, and the many additions to the Royal Victoria Hospital at Netley. But in France the hospitals were by themselves, and on a scale of vastness far exceeding anything in England. At Etaples, for example, there were 13,000 beds, divided into groups of 1,000, each completely self-contained. So great, indeed, was the scale of provision that one of these groups was for the accommodation of women patients only, to meet the needs of the great numbers of women working with the armies in the field. The heroism of these ladies, and the brutal conduct of the enemy, in connection with the air attack on Etaples, is a matter too well known to need more than a passing reference.

This hospital work in France, however, belongs to a somewhat later period of the war than that to which our narrative has reached. Allusion is only made to it because all the subsequent work, after October, 1914, was based on Major Armstrong's types modified to suit circumstances. It was of supreme importance to have the type well

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established at the first, and that certainly was done. The normal hospital construction began in the large camps concurrently with other work, though as a rule it was not finished till other accommodation was complete.

## XII.

During the winter of 1914–15 the hutting programme proceeded rapidly. Building work in the country generally was at a standstill. The Ministry of Munitions had not yet arisen, with its rival allurements, and there was little talk as yet of "push and go." The building trades had numbers of men who were either too old for military service or had some other reason for not enlisting. Some, at least, wished to "do their bit" by building work at home, even in places entailing discomfort and hardship. Materials, except galvanized corrugated steel, were plentiful, and the timber shortage was not felt, or, at least, was only in the early stage of scarcity. There was ample employment for most of the building trades, except for plasterers and slaters, and even for these there was some provision made. Thus it is interesting to see that the curve of production rose rapidly in the winter months, despite the unusual inclemency of the weather.

The principal centres of activity were the Southern and Northern Commands. In the former the chief area of intense work was round Salisbury. In addition to new hutted camps near Tidworth and Bulford, there arose a new hutted town at Larkhill, near Stonehenge, camps along the Wylye Valley from Salisbury to Warminster for two divisions, another in the Fovant Valley for one division. Round Winchester there were huts for two more divisions, two huge remount depôts at Romsey and Southampton, and a third near Bristol. At Wareham and Bovington in Dorsetshire there was another division. Altogether the new accommodation in the counties of Wilts, Hants and Dorset amounted to the needs of some 250,000 men. It is a matter of surprise that the splendid training ground of the Cotswold Hills (proved, in the autumn manœuvres of 1909, to be admirably suited to the training of troops) was not utilized. If this had been done (and it was recommended on engineering grounds) the congestion near Salisbury, with its inevitable delay and expense, would to some extent have been lessened. But the nearest place to that open country where troops were hutted, was at Chisledon, near Swindon.

In the Northern Command there were some very large camps, but they were at considerable distances apart. At Ripon and at Richmond (afterwards called Catterick), and at Cannock Chase, there were in each case two divisions, a total of 120,000. At Clipstone (Notts) and at Belton Park, Grantham, a division at each place, another 40,000. The Tyneside battalions (4) were hutted in

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the Duke of Northumberland's park at Alnwick, under the supervision of the city of Newcastle. Other cities, such as Leeds, followed this example. The total for the Command amounted to about 200,000.

The Western Command had divisional camps at Prees Heath and Oswestry in Shropshire, and Rhyl in Flint, several brigade and battalion camps and a large remount depôt near Liverpool. The total came to about 80,000.

The Eastern Command had, besides extensive additions to Shorncliffe and Colchester, divisional hutments at Halton Park in Hertfordshire (on land given by Lord Rothschild), at Seaford and Shoreham, near Brighton, and many smaller camps round London. The total was about 80,000.

The Aldershot Command is a small one territorially, but it was fully occupied. Large additions were built near Aldershot itself, and at Blackdown, Ewshott and Longmoor, which are permanent military stations. Hutted camps for a division in each case were built at Witley Common and at Bramshott (near Liphook). Total, about 60,000.

In the above summary of work in the English commands it will be observed that no mention is made of those parts of the country nearest to the enemy, the reason being that East Anglia, Kent and E. Sussex were held by Home Defence troops, and their needs were distributed in billets and in small hutted camps all over that area. Nevertheless, there were some fairly big groups of huts, *e.g.*, at Maresfield Park and Crowborough in Sussex, at Forest Hill and Canterbury in Kent, and at many places in Norfolk and Suffolk. The total amounted to about 50,000.

In Scotland there were only a few hutted camps, and those mainly for defence troops near the important naval bases of the Forth and Cromarty. Near Edinburgh (Duddingstone and Dryhorn) there were about 3,000; at Stirling, Dunfermline and Kinross, another 3,000, and near Cromarty, Invergordon and Nigg, about 4,000. In Ayrshire there were a few battalion camps of Glasgow troops, about 3,000. Altogether the accommodation there provided was for about 15,000.

In Ireland, besides large additions to the Curragh, there were battalion or brigade camps near Cork, Tipperary and Buttevant, and in Ulster accommodation for a division (which had the distinction of being the most expensive in the United Kingdom, costing £36 per man). Total, about 40,000.

In addition to this there were groups of coast defence troops, chiefly at the principal naval bases, and additions to all the infantry depôts in the country. The total amounted, in that first winter, to demands for about 800,000 men and 150,000 horses, and involved an anticipated expenditure of at least 16 millions sterling.

It was felt that in view of so colossal an expenditure it was

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incumbent on the War Office to obtain the very best professional advice, not for purposes of evading responsibility, but to obtain wholesome and sound criticism. It would be far better to scrap type plans, and existing methods of work, at an early stage, if these were faulty, far better to dismiss, wholesale if necessary, incompetent officers if such existed, than to allow any faulty and second-rate work to be tolerated and public money to be wasted. So the War Office asked the Institution of Civil Engineers, with whom there had always been the most cordial relations and co-operation, if they could appoint a committee to visit and criticize the work in progress. The functions of such a committee would be purely technical, but within that general term they would be free to criticize anything, type plan, local arrangements for water supply, roads, etc., contract methods, wages, accounting and so forth.

Lord Kitchener at first demurred to the proposal. He was satisfied with what was being done, and did not think the opinion of other people mattered. But when the point was insisted on that his own responsibility would be strengthened by good expert opinion, he agreed, for he realized that sooner or later criticism would come, and it was obviously better to have it from experts than from " the hare-brained chatter of irresponsible frivolity."

The reply of the Institution was courteous and cordial. The Committee which was nominated was the very best possible, for the Chairman was the President of the Institution, Mr. B. Hall Blyth (since deceased), and the members—Sir Robert Elliott-Cooper, Sir Maurice Fitz-Maurice, Mr. Basil Mott and Capt. H. R. Sankey, all of them members of the Council of the Institution and two of them Past Presidents. Capt. Sankey had been an exceptionally brilliant R.E. officer who, after some 16 years in the Army, had retired to take up civil engineering and had attained the highest reputation in that profession. At the outbreak of war he offered his services, gratuitously, as technical adviser and consultant to the Director of Fortifications and Works, an offer which was very gratefully accepted. Shortly after the war he was elected President of the Institution of Mechanical Engineers.

This Committee was obviously the most competent tribunal of appeal in technical matters that could be found in England. They offered their valuable services to the War Office gratuitously, and spent their very valuable professional time freely in visiting the works in progress and in reporting. In all human enterprises, especially on so vast a scale as this one, there must inevitably be many faults, big or little, and the hutting scheme was not exempt. But, taken all round, the Committee's report was very favourable. They recognized the seriousness of the situation and the magnitude of the undertaking. They considered that, on the whole, it was being adequately handled.

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Later on, this Committee was asked to criticize and advise on other engineering works and ultimately to go to France and criticize work there. But in 1915 their functions were confined to the large hutments in England, over 200 of which they visited.

## XIII.

It is not our intention, and it would be tedious and entirely out of place, to attempt to describe all, or even a few, of the large hutted camps. But it is thought that some account of one of these may be of interest, and from the description of one, an idea may be formed of the work involved in any other.

The one thus chosen for some description is that known as Catterick in Yorkshire, from the little village of that name whence the branch railway to the camps leaves the existing line. Really, the great camp or cantonment is much nearer the town of Richmond than it is to Catterick, but the confusion with Richmond, Surrey, was found to be so great that the name of Catterick was preferred.

The site was one of the last chosen in 1914, and in selecting it, the assistance of the M.F.H. of the Bedale Hunt was asked, and freely given. The situation is on the plateau to the south of the gorge of the river Swale, immortalized in Turner's pictures, and the historic town of Richmond. In 1914 this upland, partly moorland, partly pastoral and arable land, was as quiet a spot as any in England; cold and wind-swept in winter, fresh and bracing in summer.

Lord Kitchener gave instructions that in one of the Yorkshire hutted camps the possibility of having what he called "an Aldershot in the North," might be borne in mind. In other words, just as Aldershot was, at the conclusion of the Crimean War, a hutted camp for about 20,000 men and was afterwards, at great expense, made into a permanent cantonment, so there might be, after the Great War, a similar demand for a training centre in the North of England. If this were kept in view, it might be possible to give the new cantonment a somewhat more permanent character from the first, without greatly adding to the expense. It so happened that these instructions coincided with the investigation of how to reduce the amount of timber in hut construction, since the shortage of that material was now becoming a serious matter. The Catterick site furnished an opportunity of trying the use of concrete on a large scale, for the river Swale, close to Catterick, sweeps round a bend where large deposits of gravel are found. A railway from this area could be made, with easy gradients, to the site of the camps, four miles away, and easily connected with the existing line on the other side of the river. About the bridging of the Swale we shall have something to say later. Meantime, it is sufficient to say that plant for excavating and sifting the gravel was readily installed in the area in question.

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The walls and floors of the new huts were thus projected as of concrete, the former either in slabs, or in fine mortar laid on a network of expanded metal. The floors were of concrete covered with asphalt.

The framework of the huts and of the roofs was light steelwork, and the roof covering of roofing felt on planking.

The contractors who carried out the work, and devised most of the engineering expedients connected with it, were a firm of great colonial experience, which enabled them to take a wide and far-seeing view of the case. The Superintending Engineer, Colonel Exham, who, as previously stated, had built the great dockyard at Rosyth, was a man of great practical experience and power of command.

This hutted camp was one of the very few which was entirely self-contained. Others obtained, perhaps, their water supply or their electric power from existing municipal organizations, or were otherwise to some extent dependent on existing agencies. But in the case of Catterick everything was new—roads, railway, water-works, electric supply, sewage works, and even swimming-bath and laundry. The accommodation provided was for two divisions complete (40,000 men), and the camp was divided into two main parts, named Hipswell and Scotton, after the two principal houses in each area.

The railway into the camp is connected with the main line to Richmond, near the village of Catterick, and in its course has to cross the river Swale, over which a girder bridge was built. While this bridge was under construction the line was temporarily laid over an old stone bridge of three arches, which carries the main road from York northwards. This old bridge was built in the year 1426, in the reign of Henry V., and the original contract for it is in the possession of the present lord of the manor, whose ancestors have held the land ever since. Excellent, indeed, was the work of the stout fifteenth-century masons, for their arches have not only stood for 500 years, but they actually, at that advanced age, carried a broad-gauge railway, with (probably) a 100-ton locomotive, without showing any signs of failure. And it may fairly be said that the men of England and Scotland who went to the camp for training in the reign of King George V. were not unworthy of their forbears who fought at Agincourt and Flodden.

It is satisfactory to know that Lord Kitchener's wish is now being fulfilled and that an "Aldershot in the North" is coming into being at Catterick Camp, though most of the other hutments in Great Britain have disappeared.

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# *THE ERECTION OF AN INGLIS BRIDGE IN WAZIRISTAN*

*By* CAPTAIN C. DE L. GAUSSEN, M.C., R.E., Commanding 19th (Field) Coy., Royal Bombay Sappers and Miners.

IT would be interesting to know if the Inglis Bridge, of which the building is described in this article, was the first to be erected for permanent use, as opposed to temporary or semi-permanent use in war. It is true that peace, as yet, does not fully spread her wings over the land in which it was erected, but it is certainly intended to be permanent.

Three Inglis Bridges, Mk. I, were erected on the Sora Rogha-Razmak road. These had been sent to India at the close of the Great War and had since then been lying in the R.E. Park at Lahore, a constant source of labour to maintain and occupying very valuable space. Their employment on this road, therefore, was in every way desirable, particularly from the point of view of rapidity of erection, and the comparatively light weight of the portions to be transported over roads impossible for any traffic heavier than bullock carts.

These three bridges were erected, two over the Dwa Toi above its confluence with the Baddar Toi to form the Takki Zam, and one further forward over a gap near the village Marobi, where the road leaves the line of the river bed and traverses higher ground over a series of *raghzas*. This last was the first to be erected and is the one described. The gap is normally dry, about 80 ft. deep, and 60 ft. between the abutments, which were built on firm rock of very suitable formation for the purpose.

The difficulties to be overcome were human and geographical rather than engineering. The inhabitants of this part of the Waziristan are particularly troublesome, and it was essential to complete the collection of stores, erection and launching of the bridge in the minimum time, partly in order to withdraw the protection troops covering the operation as early as possible and partly to get the counterbalance bays back so that the launching of the other two bridges would not be delayed. It should be realized that, even though no definitely hostile action was taken by the Mahsuds, anything of an easily movable nature would be stolen if left unguarded, either for its material value or for " pure cussedness." A *badragga* guard (armed inhabitants paid for escort or guard duty by the government) was therefore arranged for and the dwellers of Marobi warned that any tampering with the bridge would entail the destruc-

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tion of their happy homes. Even so, five large pins disappeared, perhaps because of their potential value as weapons.

The transport available was bullock carts for the transoms and stiffeners and mule carts for the lighter parts—tubes and roadbearers. These had to be taken over a very rocky river bed as far as the last mile and a half, which was along the unfinished formation of the new road, and for the most part up a steady and very rough incline. The component parts of the nine bays (five for the bridge, one for the trolley and three for the counterbalance) were thus brought up to the site in two days. The site was cramped and unsuitable for the reception of the stores, as they all had to be unloaded in the cutting approach to the bridge, and there was great congestion throughout the day (the working hours being limited by the necessity of protection) so that stores had to be off-loaded as they arrived, and were consequently dumped in complete chaos.

On the following day, while the trolley and its pyramid were being erected by one party, the other was laying out stores ready for erection. It may be noted here that it was found necessary when working with Indians to increase the numbers of men, for carrying, over those allowed for in the drill, by about 50 per cent. This laying out took longer than would normally be the case owing to the cramped space between the sides of the cutting. The erection was then commenced, but care had to be taken, as the erecting ladders were not so strong as they had been before their sojourn in Lahore, even after repairs. However, good progress was made, with parties working at both ends, and early the following day the erection was complete.

Meanwhile the very rough road had been levelled in front of the trolley wheels and large stones placed where the channels would be laid, to minimize sinking. An anchorage and preventer tackle was made in rear of the bridge, and hauling tackle from an anchorage on the high road side above the abutment on the far side of the gap (where the road made a sharp turn) took the place of a derrick. The approach to the bridge was down a gradient of about 1 in 18, and as the preventer tackle was not too trustworthy the launching had to be taken very slowly with the frequent insertions of chocks under the wheels, to give time for the channels to be moved forward. The need for an articulating joint was felt, as, in spite of preliminary excavation, the end two transoms firmly fouled the slope of the road when the bridge was about 18 inches short of its final position. The hauling tackle was most useful in giving just the necessary lift to the front transom to seat it on the abutment, owing to the sag in the bridge. The road was then excavated below the two rear transoms to the exact distance the bridge had to go forward, and when the counterweight was replaced the slope was sufficient for the bridge to move gently forward under its own gravity and it quietly came to rest in its correct position.

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The bridge was thus erected and launched in two days, and the dismantling and laying of the roadway commenced at once. It was considered that the timber flooring supplied with the bridge would be far too tempting to the Mahsuds, to whom such baulks would be worth their weight in gold, and a decking of corrugated iron, wired down to the roadbearers and covered over by three inches of concrete, was adopted. Fortunately large quantities of clinker were available near by from some smelting process carried on in Marobi, and thus the dead weight of the deck was appreciably less than would be the case had ordinary shingle been used as aggregate. The curb was reinforced, consolidated into the decking by a stirrup round a wire laid in the floor just inside the edge of the curb.

It cannot be claimed that any valuable engineering lessons were demonstrated, but such a use of the Inglis Bridge is interesting and it established a landmark in the history of Waziristan, when a girder bridge was in two days thrown across a chasm-like gap in the heart of the Mahsuds' country.

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## *SOME SUGGESTIONS FOR LIGHTENING THE PONTOON BRIDGING EQUIPMENT.*

*By* CAPT. AND BT. MAJOR A. C. FINNIMORE, M.C., R.E.

(1) *Stainless Iron and Steel.*—The progress of invention has at all times suffered from the objection to " newfangled " devices which is deeply implanted in the average man. This is perhaps the explanation of the continued use of gunmetal in ordnance equipment such as, for instance, the coupling hooks of pontoons, of galvanized steel in wire rope, and of carbon steel for cutlery of all types.

The possibilities of the rustless alloy known as stainless steel were appreciated during the war by the designers of aeroplanes ; and this metal was used considerably for the wire stays and tensioning screws which stiffened the wings of aircraft, and also for the plates and brackets to which the stays were attached. The great strength of the alloy, and its absolute freedom from corrosion, enabled a large saving in weight to be effected ; its reliability and resistance to frictional wear made it preferable in many cases to aluminium alloys, whose lightness caused them to be used extensively where the stress was not so great.

The main objection which lies in the way of utilizing rustless steel and iron for all equipment is the large cost of these alloys. On further examination it appears, however, that the cost of an article made of stainless steel is not necessarily more than if it were of bronze. Bronze castings are known to be comparatively unreliable, and their tensile strength is low, of the order of 10 to 12 tons per square inch, while good rolled bronze seldom exceeds 26 tons in ultimate tensile strength.

The ordinary qualities of stainless steel have a strength of about 80 tons ; special qualities, after forging or drawing, may attain a tensile strength of 120 tons per square inch, while the newly evolved stainless iron averages 60 tons.

This last alloy has been evolved as the result of a search for a metal which, while retaining the same immunity from corrosion as stainless steel, has a ductility sufficient to enable it to be used for rivets, and a reliability under repeated shocks and reversals of stress to warrant its use in chains, engine rods, and steel structures.

The cost of the alloy is at present about twice that of Admiralty bronze, while its strength is from twice to six times as much.

As regards facility of working, suitable mixtures can be produced

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for casting, and with suitable heat treatment the ductility and reliability of a forging can be obtained in such castings.

All the stainless steels can be forged, and the milder steels and irons can be welded with as much reliability as low carbon steels or wrought iron.

The high temperature required to render the alloy plastic necessitates the use of oxy-acetylene flame or electric arc welding; but such methods of welding are now familiar to all engineers and manufacturers.

A particular use for which these properties commend the employment of stainless iron alloys is in the fastenings of pontoons and bridging superstructure, where weight is a serious disadvantage, and where freedom from corrosion is so essential that bronze has been considered necessary in the past.

(2) *Anchors.*—A considerable saving of weight in the equipment could be effected by substituting for the 112 lbs. and 56 lbs. anchors as provided at present a more effective anchor of much less weight.

The present type of anchor frequently acts only as a deadweight on account of its ineffective form; and it is therefore necessary to supply sufficient metal to hold fairly well even if only lying on the bottom without hooking in. Fishermen in some places use anchors weighing not more than 20 lbs. to hold boats in conditions much more severe than those encountered in bridging streams, knowing that the weight need be no more than enough to commence to drive in the point, if the anchor is correctly formed.

*Fig.* I shows the present equipment anchor. It is equally likely to fall point downward or with the flukes horizontal, and in the latter position is stable, so that it may drag without turning over

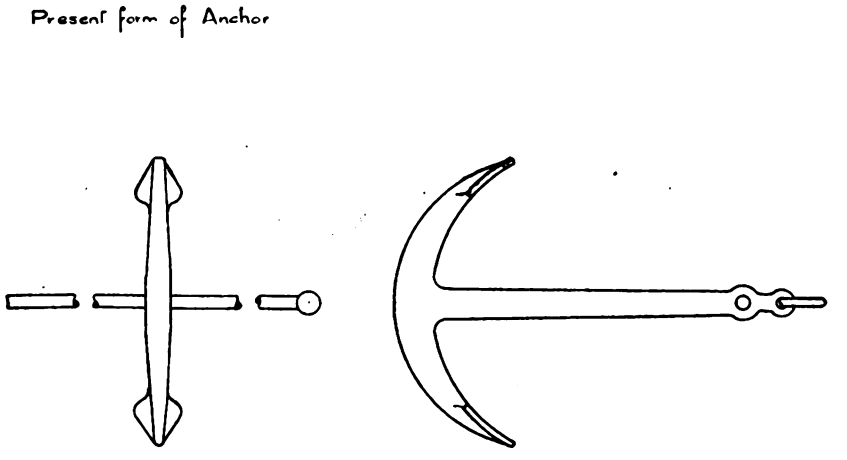


Fig 1

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and biting, as in *Fig.* II. Its points are blunt, and the palms are barbed, so that if the rope happens to take a turn round the palm, it is likely to stay there and drag the anchor crown foremost.

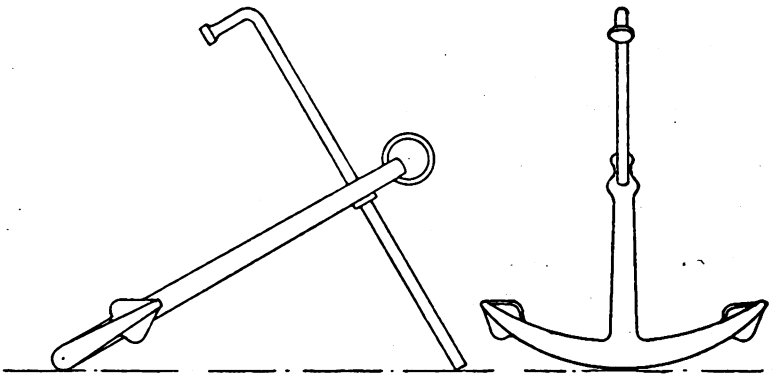

Fig II

*Fig.* III shows the fisherman's anchor. Its long shank and flukes at 45° ensure that, if once the point enters, the pull on the ring will drive the fluke further in. The long stock, of considerable weight, makes the anchor very unstable if it happens to fall with the flukes horizontal, as in *Fig.* 4 (*a*), and a very small tilt ensures that it will fall over with a point downward—(*b*) and (*c*). Moreover, the point is sharp ; and the palm has no barb, so that an accidental turn round it slips off easily.

Such an anchor is certain to bite, and so needs no weight except such as is necessary to provide sufficient strength. In mud or soft clay, such as is found in the beds of many comparatively sluggish or tidal streams, the form of an anchor is of small importance, because anything sufficiently heavy sinks in and then resists any attempt to move it. It is on a sandy or gravelly bottom that anchors tend to drag without biting, and in consequence of experience in such difficult places that the demand for weight arises. This demand is equally well met, however, by an anchor that will bite with certainty.

Anchors seldom fail by dragging when once bit, but rather by failing to bite at a critical moment, or by being fouled by a rope. A bad foul, such as a half hitch thrown round one fluke, will put any anchor out of action ; but it is extremely unlikely to occur, unless by dropping a coil of rope over the fluke before, or in the act of, lowering away.

It is the plain turn or half turn on a fluke or the stock which generally causes trouble by turning the anchor over and leaving it with flukes horizontal. It is important, therefore, that the anchor

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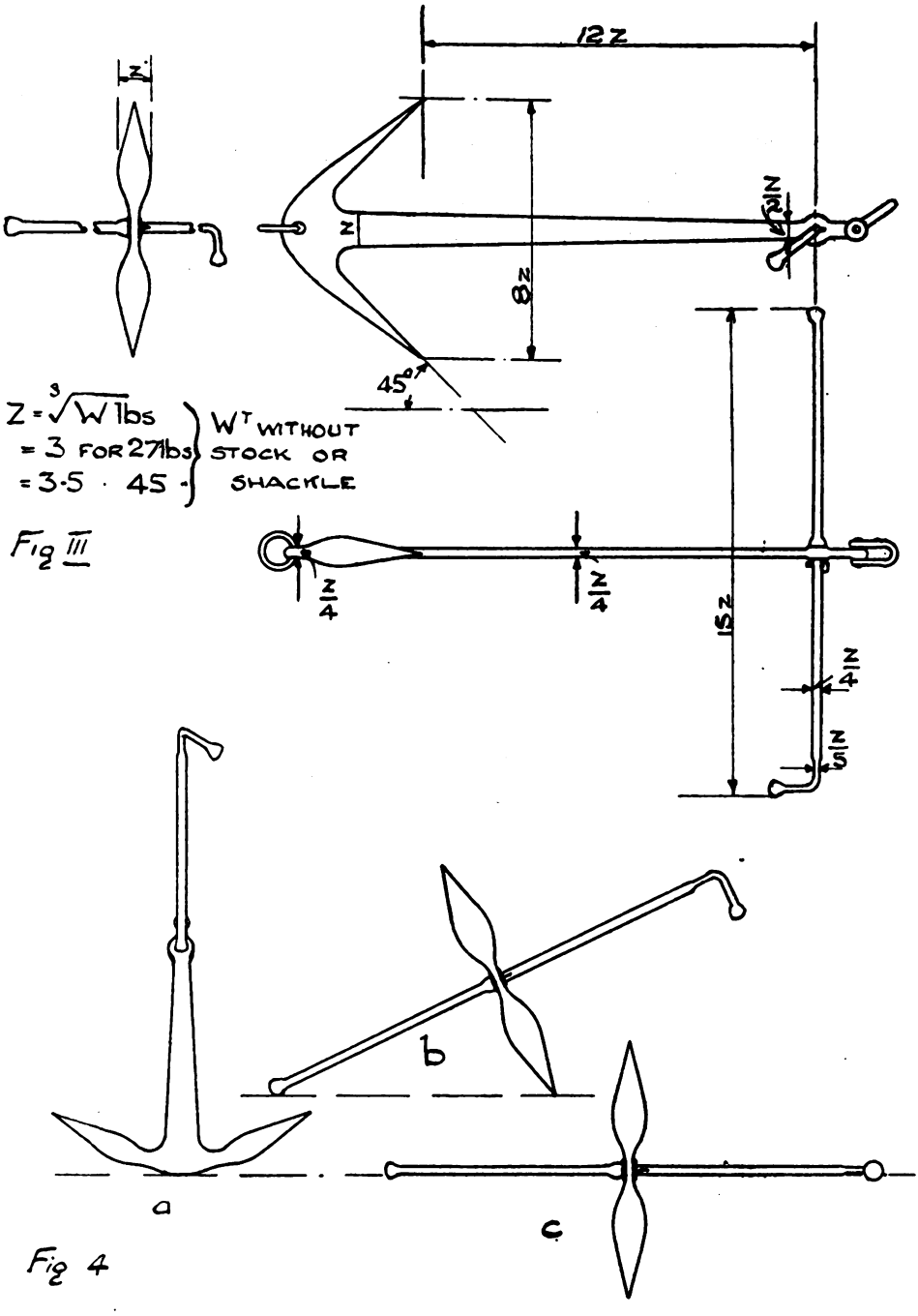
Fisherman's Anchor




$Z = \sqrt[3]{W \text{ lbs}}$ } W^T WITHOUT
= 3 FOR 27lbs } STOCK OR
= 3·5 · 45 } SHACKLE

Fig III

Fig 4

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shall be unstable in this position, so that it will fall over point downwards when any pull comes on the cable. It is also equally important that the form of the fluke shall permit the cable to slip off the fluke it has fouled; and anything of the nature of a barb is likely to increase the chance of remaining foul.

It will only be possible to determine the minimum weight of anchor that can safely be applied to the purpose of bridging as a result of practical tests. It may safely be predicted, however, that much lighter gear could be so applied than is in use at present; and at a hazard, the nominal weights of 43 lbs. and 27 lbs. are suggested as sufficient to replace the present types.

The nominal weight does not include the stock or shackle; the gross weights corresponding are 57 and 36 lbs. respectively.

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# *THE EARLY YEARS OF THE ORDNANCE SURVEY.*

*(Continued).*

## III. The Survey is Formally Founded.

**The Duke of Richmond.**—If it is to General Roy that we owe the first conception of a National Survey, it is no less certain that it was the Duke of Richmond who made the scheme possible and created the department officially. Throughout the early records of the Survey numerous references will be found to the practical support given by the Duke to the geodetic operations which were, in those days, under the general control of the Royal Society; and, when the proper time came, it was the Duke who took the initiative and converted what was, till then, mainly a scientific undertaking, into a National Survey. In the preface to the *Account of the Trigonometrical Operations*, by Captain Mudge and Mr. Dalby, it is stated that "the design . . . had not, in its origin, that extensive application which has since attended the endeavours of his Grace the Duke of Richmond, with respect to subsequent trigonometrical operations." In 1791 we find the Duke issuing instructions "to be minute in our Survey of Sussex" with a view to the construction of a map of that county. In 1794 he directed that the operations for that year should commence in Kent and be continued till that county was finished and then be carried over into Essex. Earlier General Roy stated that "the Duke of Richmond, Master General of His Majesty's Ordnance, had, in the most liberal manner possible, given every assistance to the operation (from that great department over which he presides with so much honour to himself and advantage to the publick)." Lieut.-Colonel Edward Williams, the first official Director of the Survey, speaks of "the liberal assistance which his Grace the Duke of Richmond had on all occasions given to this undertaking," that is, to the early operations under the Royal Society. And Portlock, writing in 1853, stated that General Roy particularly acknowledged the attention that the Duke always paid to his representations, and that it was from the Duke that the idea of a National Survey received its earliest and most decided support. Portlock adds, "Taking, then, into consideration the encouragement he conferred on this peculiar branch of the Ordnance service—asserting, by so doing, the claims of Ordnance officers to be looked upon as scientific men—the patience with which he investigated the now popular subject of national defence, and the personal attention he

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bestowed on all the military departments of the Ordnance, including the Royal Military Academy, it may be justly said that the Duke of Richmond stands in the first rank of Masters-General of the Ordnance."

Charles Lennox, 3rd Duke of Richmond, was born in 1735, and succeeded to the title in 1750. He entered the Army, and distinguished himself at the Battle of Minden. After the peace he was appointed Ambassador to Paris (in 1765). On his return he took a large part in public life, embraced the cause of the American Colonies, and denounced the Ministerial policy. In December, 1775, he declared that the resistance of the colonists was "neither treason nor rebellion, but is perfectly justifiable in every possible political and moral sense." At this period King George III. entertained a strong personal dislike for the Duke, but after the close of the war they became friends; and a few years later the King said that "there was no man in his dominions by whom he had been so much offended, and no man to whom he was so much indebted, as the Duke of Richmond."*

He was appointed Captain in the 20th Regiment of Foot in 1753, and received the rapid promotion to be expected in those days in the case of a man of his position and ability. He was promoted to Major-General in 1761 and was made a Field-Marshal in 1796. He appears to have been particularly interested in two subjects which are dealt with by the Engineers of our Army, namely, fortification and surveys. In 1783, as Master-General of the Ordnance, he appointed General Roy a member of the Board on Fortifications, over which he himself presided. In the same year he nominated a special committee to consider the defences of Chatham. He was supported by Pitt in his proposals to remodel the fortifications of Portsmouth and Plymouth; but the House of Commons, alarmed at the probable expense, threw out these proposals, after a division which required the casting vote of the Speaker.

The existence of the Ordnance Survey is evidence as to his interest in surveying. Not only did he, during Roy's lifetime, give the most effective assistance, in this matter, to the Royal Society, of which Society he was a Fellow, but after Roy's death he took the decisive step of putting the Survey under the Board of Ordnance, and thereby established it as an official department. But for the Duke of Richmond the National Survey, if it had come into existence at all, would almost certainly have assumed a different and less efficient form; and it was a fortunate thing for the Survey, not only that it came under the Board of Ordnance, but that the Master-General was well acquainted with Roy and his work, and was able to preside over its destinies for the first few years.

* *Dictionary of National Biography.*

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The Duke was a man of the widest interests; fond of country life and sports, a patron of literature, science and the fine arts, a soldier of distinction, and a statesman of far-seeing views. He was a great friend of Romney; Goodwood contains many examples of this artist's work, painted to order of the Duke. He was much interested in the work of "that able artist Mr. Ramsden"—an artist in brass and glass. Indeed there were few aspects of life in which he was not interested. Burke is said to have reproached him with spreading his talents over too wide a field. It does not appear, however, that the objects of his interest suffered in consequence. Amongst them may be mentioned racing; he made the famous racecourse at Goodwood. In the *Sporting Magazine* for April, 1801, may be found the following notice: "The new racecourse on the Harroway, near Goodwood, the seat of his Grace the Duke of Richmond, is now completely formed for sport, and much admired by acknowledged amateurs of the Turf."

Many stories are told of his fondness for hunting and of his autocratic, if kindly, ways as Master. "Such was his Grace's desire to give fair play to a good fox, that once, after a capital run, the fox having sought refuge upon the porch of Waltham Church, which was covered with ivy, but not sufficiently to conceal his brush from the view of his pursuers, who with their whips were trying to dislodge him, the noble Master rode up in great haste and anger, asking them to desist, and exclaiming, "Why do you want to murder such a fox? leave him alone. He has shown you a good day's sport, and if left will show you another."*

The Duke was appointed Master-General of the Ordnance in March, 1782, and retired from that position in February, 1795, being succeeded by Lord Cornwallis. The appointment is not to be confused with the less important post which nowadays carries the same name. In those days the Honourable Board of Ordnance was a great department, possessing extended powers. Its history dated back to the middle of the fifteenth century, and for four hundred years it maintained a tradition of independence and authority. The Master-General was responsible for the Artillery and Engineers of the Army, for fortifications and armaments, and all things therewith connected; he was one of the King's principal advisers, and was at all times a military power to be reckoned with. In later years the position was held by the Duke of Wellington. The Duke of Richmond's tenure of the appointment covered those ten years, a brief breathing space, between the war with the American Colonies and their allies, and the war with revolutionary France, extending on into the latter. After his retirement he lived almost entirely at

* *Records and Reminiscences of Goodwood and the Dukes of Richmond.* John Kent. Sampson Low, Marston & Co., Ltd. 1896.

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Goodwood, where he died on the 29th December, 1806. He was buried in the Cathedral Church of Chichester.

The Ordnance Survey, which preserves in its name the history of its creation by the Honourable Board, and is the last surviving branch of that ancient institution, is always bound to keep in pious remembrance the name of the distinguished Master-General who founded it.

**The word "Ordnance."**—The word "ordnance" is a syncopated variant of "ordinance," which is itself derived from the old French word "ordenance" (a regulation and an arranging in order). In the seventeenth century the word "ordnance" came to be exclusively applied to artillery and engineer personnel and material, and the services relating to these.* In the early days of the Survey the expression "Ordnance Survey" was not used, at least officially. Thus, in 1811 was published the third volume of the account of the *Trigonometrical Survey carried on by order of the Master-General of His Majesty's Ordnance*, and the work is sometimes alluded to as the British Survey, or the British Trigonometrical Survey, or the General Survey of Great Britain. In a letter dated 1817, from the Master-General of the Ordnance to the Lord Advocate of Scotland, the expression "Ordnance Map" is used. The first use of the term "Ordnance Survey" that can be found is in a minute dated 1820, when the "eighth part" of the *Ordnance Survey* was presented to the Duke of Wellington, then Master-General; in this sense it meant the map itself. In 1827 the official *Instructions for the Interior Survey of Ireland* are stated to have been lithographed at the *Ordnance Survey Office*, Phœnix Park. In 1842 the official account of the Zenith sector observations is headed *Ordnance Survey*. The term, which naturally arose from the fact that the Survey was administered by the Board of Ordnance, is a very convenient one and saves the use of a longer expression. It became, in after years, the synonym for a Survey of the highest accuracy.

**Effect of Roy's Death.**—If we wish to measure the influence of a particular factor in any of the affairs of life we can sometimes arrive at a just conclusion by imagining the effect produced by the removal of that factor, or by watching the result of its removal. And the best proof of the large share that General Roy had in shaping these early Surveys, is that on his death they, for a short time, stopped altogether. In the *Account of the Trigonometrical Survey* for the years 1791–94, by Lieut.-Colonel Edward Williams, Captain William Mudge and Mr. Isaac Dalby, it is stated that some time elapsed after the General's decease "without any apparent intention of renewing the business." Portlock says that "after General Roy's death the subject of a Survey seemed, for a time, to be overlooked"

* See *The Oxford Dictionary.*

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**The Official Foundation of the Survey.**—The account above mentioned goes on to say that " a casual opportunity presented itself to the Duke of Richmond of purchasing a very fine instrument, the workmanship of Mr. Ramsden, of similar construction to that which was used by General Roy (*i.e.*, a second 3-ft. theodolite), but with some improvements ; as also two new steel chains of one hundred feet each, made by the same incomparable artist. Circumstances thus concurring to promote the further execution of a design of such great utility, as well as honour, to the nation, his Grace, with His Majesty's approbation, immediately gave directions to prepare all the necessary apparatus for the purpose, which was accordingly provided in the most ample manner." According to another account, the Duke of Richmond purchased a 3-ft. theodolite, intended for the East India Company. Portlock says that the Duke, being informed that Ramsden had made this second instrument and the two chains, " recommended to the Government that they should be purchased and the work renewed." The 3-ft. theodolite in question is known as the 3-ft. O.S. ; it is now (1924) in the Science Museum, South Kensington, and has the date 1791 engraved on the circle. The reason given for the official prosecution of the Survey is not convincing. The undoubted facts are, that Roy died in July, 1790, and that, as we shall see shortly, officers were appointed to the duty of carrying on the Survey in July, 1791. With regard to the preoccupations of the Master-General, the French Revolution had been in progress some little time—the Bastille fell in July, 1789—but France and England were not at war again until February, 1793. No doubt this was a busy time at the Board of Ordnance, but not so busy as to prevent the discussion of the question of the continuance of the Survey. It must, of course, be remembered that up to Roy's death the operations had been carried out under the general direction of the Royal Society, with assistance from the Board, and that the instruments used had been paid for personally by the King. But the instruments were still available and it is difficult to believe the official story, published after the Duke had ceased to be Master-General, that it was the knowledge of the existence of a second theodolite which caused him to adopt the Survey officially. Such a reason appears to be quite inadequate. Official statements, however old, do not always carry conviction. The course of events was probably something like this: The Duke of Richmond was genuinely interested in Roy's work and we know that he had always materially assisted him. On Roy's death the Duke cast about for some means of continuing the Survey, and no doubt consulted the Royal Society, of which he was a Fellow. The military authorities, in view of the probability of war with France, realized the value of a trustworthy map of Southern England, and the Duke, who was himself a high military authority was of the same opinion. The

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Royal Society, having seen the completion of the trigonometrical connection with France, was not unwilling to be relieved of further responsibility for the Survey.

It is known that the Duke applied to Dr. Hutton, of the Royal Military Academy, Woolwich, for his opinion as to the best officers of the Artillery and Engineers to take charge of the Survey, and that Dr. Hutton recommended Major E. Williams and Lieut. W. Mudge, both of the Royal Artillery. "Dr. Hutton said that in so doing he sincerely believed he had named the best mathematicians in the two Corps, and the fittest officers for this duty. Indeed, he added, it would have been very difficult to have found persons better qualified anywhere."*

During the course of a year the various negotiations with the financial authorities, with the Royal Society, and perhaps with the East India Company, and with Ramsden with regard to the second instrument, were concluded satisfactorily and in July we find the two officers above-named definitely appointed, as shown by the following *Extract from the Minutes of the Master-General and Board of Ordnance*† :—

12th July, 1791.

"G. W. Phipps, Esq., Under Secretary to the Master-General, having, by letter of the 10th inst., signified that his Grace had appointed Major Williams and Lieut. Mudge, of the Royal Regiment of Artillery, to carry on the Trigonometrical Survey with the assistance of Mr. Dalby, and desired that they might receive an Extra Allowance equal to their pay and half-pay whilst actually in the field which would be 22s. 6d. per day to Major Williams and 7s. 6d. per day to Lieut. Mudge besides the usual allowance per mile for travelling from place to place and that a party of Artillery who were to assist were to receive one shilling per day each while employed."

"Ordered that the above Allowances be paid."

It may, therefore, be taken that the date of the official constitution of the Ordnance Survey was the 10th July, 1791. The personnel of the Survey consisted of the three above-named, Major Williams, Lieut. Mudge and Mr. Isaac Dalby; they were assisted in the field by a working party of artillerymen. Poles, scaffolds, ladders and such apparatus were provided by the Board of Ordnance. Williams, Mudge and Dalby all worked in the field and Dalby was especially responsible for the computations. The principal instruments used were the new 3-ft. theodolite of Ramsden (the Royal Society theodolite was not used again until January, 1799, being meanwhile laid up in the apartments of that Society), two new 100-ft. chains, and a transit instrument combined with a telescopic level, for use in measuring bases, all by Ramsden.

* *Memoirs of the Mudge Family*. S. R. Flint. Truro. Netherton & Worth. 1883.

† Communicated by Mr. Cary, the War Office Librarian.

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It may be interesting to note that the fame of Ramsden's instruments had by this time spread over the world. In the same year (1791) the German geodesist Johann Georg Tralles and the Swiss geodesist Ferdinand Rudolf Hassler, of Aarau, measured a base-line $7\frac{3}{4}$ miles long together, for the Survey of Switzerland, using a steel chain made by Ramsden. Later on, the government of the Canton of Berne voted six hundred dollars for the purchase of a suitable theodolite and " Mr. Ramsden in London, then the most celebrated instrument maker living, for a sum somewhat exceeding this amount, promised to supply in 1794 a complete azimuth circle, at least three feet in diameter. Due to various delays the great instrument did not reach Berne until 1797 . . . Ramsden's three-foot theodolite was a wonderful instrument . . . What a privilege for young Hassler to become practically acquainted with the use of an instrument of the high type that very few surveyors then living had ever seen ! The three years' delay is characteristic ; we have seen that Roy suffered from a similar delay in the provision of the first theodolite."* The young Hassler was afterwards the founder of that admirable department, the United States Coast and Geodetic Survey, which was suggested by him in 1807, approved by Congress in the same year, but not actually organized until 1816, Hassler being the first Superintendent.

**The First Director.**—The following are the services of Edward Williams as recorded in the *List of Officers of the Royal Artillery* :— Siege of Belle Ile, 1761 ; Adjutant, North America, 1777 ; on the Staff of Lord Hood ; on the Staff of General Pattison, Governor of New York, 1775–1780.† (Belle Ile is an island some eight miles south of the peninsula of Quiberon, in Brittany, about midway between L'Orient and St. Nazaire ; it was captured in 1761, and was held by British troops until 1763, when it was exchanged with the French for Nova Scotia. The next thing we know about Williams is that, as already mentioned, he was recommended by Dr. Hutton as an officer whose mathematical attainments fitted him to take charge of the Survey ; he was a Major when he was appointed, in July, 1791, and if we may assume that he was at least 18 at the siege of Belle Ile, he would have not been less than 48 years old when he first took charge of the Survey. In collaboration with Mudge and Dalby he wrote the account of the Survey for the years 1791–94 ; he was then a Lieut.-Colonel. With them also he wrote the account for 1795–96, being then described as Colonel He died in 1798, and it is curious to note that Mudge, in his account of the operations for 1797–99, makes no mention of Colonel Williams or of his death.

* *The Scientific Monthly*, Aug., 1921. Article by Professor Florian Cajori on *Swiss Geodesy and the U.S. Coast Survey.*

† Kindly communicated by the Secretary, R.A. Institution.

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We may, perhaps, suppose that he was in failing health for some years, and it is not unlikely that Mudge was in effective charge of the work. At the best, Colonel Edward Williams, R.A., the first official Director of the Ordnance Survey, is to us but a shadowy and unsubstantial figure; we know nothing of his form or features, and, beyond the fact that he was a good mathematician, nothing of his abilities or character.

**The Headquarters of the Survey.**—From 1791, for fifty years, the offices of the Survey were in the Tower of London, which was the headquarters of the Board of Ordnance. On a plan made about 1685, by order of Lord Dartmouth, Master-General of the Ordnance, the office of the Ordnance is shown on the south side of the enclosure, touching the Lanthorn Tower and the Constable's Lodging. This was a small building and probably only supplied for the general administration of the department. The Survey offices were almost certainly in an armoury to the north of the White Tower, abutting on the Bowyer Tower; the site of this armoury is now occupied by barracks. About 1791 the Master-General appears also to have had an office in Pall Mall. However, it was to the Tower that Williams, Mudge and Dalby returned after their season's work in the field, and many of the early letters are written from the Drawing Office in the Tower.

**The Royal Military Surveyors.**—The chief draughtsman in the Tower was Mr. Gardner, who is thus mentioned in the account of the operation for 1791–94: "We have to acknowledge the services of Mr. Gardner, Chief Draughtsman at the Tower, by whose assistance, from his intimate knowledge of the county of Sussex, we have been able to determine, with certainty, the names of many places, which we might otherwise have considered as doubtful." In the accounts for 1795 "Mr. Gardner, Chief Draughtsman in the Tower," is stated to have accompanied Mr. Dalby into Kent, to assist in observing with a small theodolite. Portlock says that a Corps of Surveyors and Draughtsmen had been established by the Duke of Richmond; and if so, this Corps must have been formed before 1795. The "Corps" was to be employed for filling in the topographical details required for the one-inch maps; Mr. Gardner may have been an official under the Board before the formation of this Corps. In the preface to the account of the Survey for the years 1800–09 it is stated that the secondary triangulation in the south of England was "made subservient to a regular Survey, performed by the Royal Military Surveyors," who are presumably the Corps of Surveyors and Draughtsmen mentioned by Portlock.

**The Operations of 1791-98.**—We have seen that Williams, Mudge and Dalby formed the Staff of the Survey on its foundation in July, 1791; and that they had available Ramsden's new 3-ft. theodolite, originally intended for India, two new steel chains specially made

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by Ramsden, and minor instruments. Their headquarters was the Tower of London, and they were immediately under the Board of Ordnance, which provided for them a working party of artillerymen and all necessary material.

The first thing that they set out to do was to re-measure, with Ramsden's new chains, the base on Hounslow Heath that had been measured in 1784 by Roy. It is not necessary to go into the details of this measurement, beyond saying that the chains were supported in wooden coffers, which rested on trestles; the trestles were those used by Roy and were lent for the purpose by the Royal Society. The measurement began on the 15th August, in the presence of Sir Joseph Banks, Dr. Maskelyne, Astronomer Royal, and several other members of the Royal Society. It was finished on the 28th September, Dr. Maskelyne, Dr. Hutton, Professor of Mathematics in the Royal Military Academy, and Mr. Ramsden being in attendance, by desire of the Duke of Richmond. Every precaution was taken and the mean of the two measurements was found to be $2\frac{3}{4}$ inches longer than Roy's glass tube value. The mean of the two results of 1784 and 1791 was accepted as the true length of the base, namely, 27404·2 feet.

On the approach of the Spring of 1792 a reconnaissance was made of the country about to be triangulated, which included some of the points already observed as by Roy. Lamps, to observe to, " were constructed by Mr. Howard of Old-street, which were afterwards found equal to everything which could be expected of them." Later on in the year observations were made with the new 3-ft. instrument, at the Base, and on hills as far to the west as Butser and Chanctonbury Ring. Certain points on the coast were intersected " for the construction of some maps that were making for the Board of Ordnance "—no doubt, maps for defensive purposes. Early in 1793 a site for a base of verification was selected on Salisbury Plain, between Beacon Hill, near Amesbury, and the Castle of Old Sarum. This base was measured in 1794 with Ramsden's new steel chains: the measurement occupied seven weeks. The length, when all corrections had been applied, was found to be 36574·4 feet. The length as determined through the triangulation, from the Hounslow Heath base, was 36574·3 feet. But, when the same base was re-measured in 1849 with Colby's bars, its length was found to be 36577·85 feet. The latter value is, of course, of far higher weight; the error of the 1794 measurement was, thus, about 1 in 10,000. In 1849 it was stated that the guns marking the terminals of 1794 did not appear to have moved sensibly.

Meanwhile, during these seven years, the triangulation proceeded steadily along the south of England, until, by the end of 1795, a double chain extended from London to Land's End, and sufficient numbers of points were fixed in Kent and Sussex for the detail

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one-inch Survey. "The chief draughtsmen and surveyors belonging to the Drawing-room in the Tower, attended our operations in this county (Kent), and also those afterwards carried on in Essex. It was indeed for their immediate service that we renewed the Survey in this quarter, as the Master-General had given directions to prepare ample materials for completing the map which meets the public eye with this article." (July, 1800.) The organization was evidently imperfectly developed, the chief draughtsmen and surveyors (Royal Military Surveyors?) being apparently under the direct orders of the Board. In 1795 Ramsden's 18-inch theodolite was first used for the Survey of Kent.

**The Geodesy of the Operations.**—It was considered that "directions of meridians," that is azimuths, should be observed "in order to afford the necessary data for computing the latitudes and longitudes . . . it is expedient that new directions of meridians should be observed when the operations are extended in eastern or western directions over spaces of sixty miles from fixed meridians."

It must be remembered that at the end of the 18th century all the processes of the higher surveying were in a tentative stage, though the fundamental notions were very well known. The actual procedure for calculating the latitudes and longitudes of the trigonometrical points was, briefly, the following: The observed spheroidal angles were reduced to those made by the chords, the spherical excess calculated, and the triangular error equally distributed; the sides of the triangles, *i.e.*, the lengths of the chords, were computed; the curvature of the meridian for the south of England was derived from the observations of 1787–88, between Greenwich and Paris; from this curvature the latitude of one of the connected stations was calculated as deduced from Greenwich, then the latitude of a second connected station; then, knowing the latitudes of these two stations (say, Beachy Head and Dunnose), "and the angle which those stations make with each other and the pole," the difference of longitude was computed by spherical trigonometry. It was for the last stage on the calculation that the *observed* azimuths were required.

In those days it was easy to get a very fair value for the local curvature of the meridian, but there were obvious difficulties in obtaining any accurate determinations of difference of longitude. It will probably be agreed that the system adopted was a good one. There was no accepted, or even approximately accurate, "figure of the earth," and in practice the officers of the Ordnance Survey, at the end of the eighteenth century, measured the curvature in two directions as they went along.

**The One-Inch Map.**—From 1791 onwards for the next thirty-three years the object of the Survey is definitely the production of a one-inch map of the United Kingdom. The one-inch scale was quite familiar to soldiers in those days, and, though the public was gener-

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ally accustomed to smaller scales, there was, as a fact, a certain number of privately produced maps on the one-inch or larger scales available for general use. "In the last half of the eighteenth century a great number of county maps were published. Their issue may without much doubt be traced to the offer by the Society (the Royal Society of Arts) of a prize of £100 for the map of any county on the scale of one inch to the mile. In justification of this statement it may be said that, of the county maps mentioned by Gough in his great work on British topography, published in 1780, as being issued or in hand at that date, nearly all appear to be of a later date than 1762; and the same may be said of a list of inch maps . . . by Sir George Fordham, the great authority on this subject."* The earliest maps produced under this stimulus appear to be one of Dorsetshire, by Isaac Taylor, about which Gough states that it "is very faulty in the place names"; and one of Devonshire (1765) by Benjamin Donn, engraved by Jefferys. Donn received the £100 prize.

Other county maps, produced in response to the invitation of the Society of Arts, were those of Derbyshire (1767), Northumberland, Leicestershire, Somersetshire, Suffolk, Lancashire, Hampshire (1793), Sussex (1796), Oxfordshire, North Wales, Cardiganshire, Shropshire (1809). The maps of Hampshire and Sussex were produced by William Faden, who received £50 for the former and a gold medal for the latter. Faden also, in 1799, published a map of Kent, based on the triangulation, by permission of the Board of Ordnance. The Ordnance Survey owes a good deal to William Faden, for it was he who undertook the publication of the *Account of the Trigonometrical Survey of England and Wales*. The first volume is dated 1799, the second 1801, and the third 1811; the three volumes carry the history of the operations from 1784 to 1809. In the preface to the first volume it is stated that "Since the commencement of the operation . . . it has been always lamented that narratives of its progress should be confined to the volumes published by the Royal Society," and the Royal Society "readily acquiesced in Mr. Faden's proposal to" republish what was necessary from their translations. Faden is described as Geographer to His Majesty and to the Prince of Wales. He had a shop in Charing Cross. After Faden's death James Wyld, senior, became Geographer to the King; he was succeeded by his son, James Wyld, junior, and on the death of the latter the title was conferred on Edward Stanford, who started his business on 1st October, 1852, at 6, Charing Cross. Faden seems to have died about 1832.

* *Journal of the Royal Society of Arts*, Jan., 26th 1912. The writer is indebted to Mr. E. Heawood, of the Royal Geographical Society, for this reference.

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John Cary received a gold medal in 1804 for his map of Cardiganshire. "The name of John Cary is associated for nearly three-quarters of a century with geographical publications . . . In the manufacture of globes he worked with his better-known brother, William Cary (1759–1825), who had a considerable reputation as an astronomical instrument maker, and in the cartographical work he was associated with others of his name."* In the opinion of Sir George Fordham "Cary probably found his inspiration in respect of the art of cartographical representation of surface details" in the sheets of the map of France by Cassini de Thury, of which the earliest is dated 1756. Most of Cary's county maps were on scales smaller than one-inch, but not all, for we have a map of Oxfordshire in 16 sheets, on the scale of two inches to one mile. Cary is best known as the publisher of the road-book called the *New Itinerary; or an Accurate Delineation of the Great Roads* of England and Wales, which ran through 11 editions between 1778 and 1828.

Other county maps to be mentioned are those of Derbyshire by P. P. Burdett; Leicestershire, Cheshire and Lancashire by J. Whyman; Northumberland (1773) by Lieut. Armstrong, "said to have been a capital map," and others due to the same movement; also Rocque's map of Shropshire, produced independently. Then there is the admirable 2-inch map of Wiltshire by Andrews and Dury, published in 1773. We are here concerned particularly with maps on scales of about one-inch to one mile. Of maps on smaller scales (atlas scales) there is a long history beginning with Christopher Saxton's Survey of the English counties, published in 1579, and following on with John Speed's Atlas in 1611.

One thing is common to all these county maps; they were printed from engraved copper plates. In the earlier maps the hill features are shown in profile, as they are in the maps of ancient Egypt; in the later maps they are shown by hachuring of various degrees of picturesqueness. The public was thus accustomed to engraved county maps, which had been gradually improved since the sixteenth century. The Ordnance Survey, at the end of the eighteenth century, had these various county maps, Cassini's series, and other foreign maps, to serve as models. The well-known atlas of Bacler D'Albe, Napoleon's Directeur du Dépôt de la Guerre, published at Milan in 1795, to illustrate the French campaign in Italy, is a good continental example of an engraved hachured map of the period; the main features stand up very clearly and it is an easy map to read. The methods of copper-plate cartography reached a high standard.

**Inaccuracy of the Old County Maps.**—Picturesque and interesting as the old county maps are, they leave a good deal to be desired on

* *The Work of John Cary and his Successors.* Pamphlet by Sir George Fordham. 1924.

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the score of accuracy. Errors of 10 per cent. or more may be found on Elizabethan maps; but similar errors exist even on the eighteenth-century maps. Thus, in the preface to the first volume of the *Account of the Survey*, dated 1799, we find the following remarks: "In the prosecution of the General Survey, frequent opportunities have manifested themselves of enabling us to discover the very erroneous state of our maps . . . by laying down on the maps of counties, particularly on Taylor's map of Dorsetshire, the distances of the intersected objects, as Dorchester Church from Nine Barrow Down, where an error of nearly three miles is detected in a distance of eighteen, an immediate proof is obtained of their great inaccuracy. Taylor's map of Dorchester (? Dorsetshire) is here specified, because we think it is the most erroneous of any we have examined; yet those of Devonshire and Kent may be considered as similar specimens of imperfect topography." It may be noted, by the way, that Taylor's map, described by Gough as "a capital Survey," failed to get the Society of Arts prize. The preface goes on to say that "It has been very justly expected by the public, that from the present undertaking they should derive the advantage of an improvement in the geography of their country, and possess some general map, published on the same principle with the *Carte de France*, a performance highly celebrated."

In 1791 the Copley Medal of the Royal Society was awarded to Major James Rennell for his geographical work in India. The President, Sir Joseph Banks, in his address on that occasion, compared Rennell's map of India with the county maps of England, which were then available: "I should rejoice could I say that Britons, fond as they are of being considered by surrounding nations as taking the lead in scientific improvements, could boast a general map of their island as well executed as Major Rennell's delineation of Bengal and Bahar: a tract of country considerably larger in extent than the whole of Great Britain and Ireland; but it would be injustice to the Major's industry were I not here to state that the districts he has perambulated and planned exceed, probably, in extent the whole tract of surveyed country to be found in the maps of the European kingdoms put together, while the accuracy of his particular surveys stands yet unrivalled by the most laborious performance of the best county maps this nation has hitherto been able to produce."*

We may sum up the matter thus: At the end of the eighteenth century there were many county maps, of comparatively recent date, on the scale of one inch to one mile, or on even larger scales. These maps were printed from engraved copper plates, the hill-features being shown by hachures. The engraving was good, and the maps were generally artistic productions. But the English

* *Major James Rennell.* Clements Markham. Cassell & Co. 1895

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county maps had no pretensions to accuracy; they were inferior, in this respect, to Rennell's recent maps of Bengal, and their errors cried aloud for correction.

**The Field-work of the One-inch Map.**—In 1795 the Corps of Draughtsmen and Surveyors belonging to the "Drawing-room in the Tower," under Mr. Gardner, attended the trigonometrical operations in Kent. Mr. Dalby and Mr. Gardner used the new 18-inch theodolite for the fixing of secondary and intersected points on which to base the detail. No information is given us as to how the detail of the "interior survey" was mapped; but it appears to be almost certain that this interior, or detail survey, was carried out by compass and pacing, or cyclometer, and was executed on the 2-inch scale in the field. Although the plane-table had been known practically, in its modern form, for more than two hundred years, and although in certain parts of Great Britain, notably in the Down country, and in the mountains of Cumberland, Wales and Scotland, the plane-table is without rival as a surveying instrument for work on the one-inch and similar scales, it was never adopted by the Ordnance Survey.

The plane-table might have been most profitably used between 1795 and 1825, a period during which there was only the one-inch map to think of. The ignorance which prevailed as to the value of the plane-table lasted to a much later date. For instance, the Palestine Survey, which was begun in 1871, was carried out, as regards the detail, by means of the prismatic compass, and this in a country which is exceptionally suited to the plane-table. The explanation given is that "the N.C.O.s in Palestine were familiar with the compass and it is very handy in riding."* The writer remembers that, as late as 1897, the field training of the topographical section of the Ordnance Survey, which was intended for service abroad, was confined to the prismatic compass. However, for good or ill, the detail of the old one-inch map appears to have been surveyed inside the fixed trigonometrical points, by the compass. There was not room for much accumulation of error; and although such a procedure results in a "loose" Survey, the early sheets of the old one-inch map were, as regards accuracy, greatly superior to any previously existing maps of this country.

* *The Trigonometrical Survey of Palestine.* Major C. R. Conder, D.C.L., LL.D., R.E. R.E. Professional Papers. 1894.

(*To be continued.*)

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# *REPORT ON THE INTERNATIONAL CEMENT CONGRESS.*

*April 22nd, 23rd, 24th,* 1924.

*By* BREVET LIEUT.-COLONEL D. K. EDGAR, D.S.O., R.E.

THE International Cement Congress convened by the Institution of Structural Engineers assembled at the Congress Hall, Olympia, on April 22nd, 1924.

The morning was spent in inspecting the exhibits of the Building Exhibition then being held at Olympia, which contained too many interesting features to deal with in detail. After lunch the Congress reassembled and discussed papers placed before the assembly. The following is a brief *résumé* of the papers and discussions.

In the first paper, entitled "The modulus of density of concrete as a means of maintaining uniformity throughout," the author, Mr. Alfred S. Grunspan, B.SC., A.C.G.I., A.M.INST.C.E., points out that the density of concrete, particularly when it has to withstand hydrostatic pressure, is all-important to the engineer. To arrive at a standard of density the author has evolved a table, whereby, after measuring the voids in the sand and in the coarse material, and assuming that sufficient sand is used to fill in all the voids of the coarse material, then the granular volume of the cementitious material, represented by the cement mortar, divided by the volume of voids to be filled, represents the modulus of density.

To arrive at a uniform density throughout any large work it would be necessary to measure the voids in each consignment of sand and coarse material and so proportion the volumes used that the modulus of density remained constant. The author points out that engineers in the past used lime as an admixture to the cement in order to obtain a denser concrete; the addition of lime, however, means a reduction of strength of the concrete, although giving a denser mixture.

In concrete exposed to the action of sea-water the presence of calcium hydroxide is a source of weakness; any filler which combines with the lime set free when the cement sets and which produces a cementitious material instead of calcium hydroxide will therefore give not only a denser concrete but a stronger one. Trass or pozzuolana and also the proprietary material Novoid appear to possess the property of fixing the free lime, and give good results.*

* *Note.*—This property is also possessed by silicate of soda, which is discussed in a later paper.

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In the discussion that followed, the difficulty in accurately measuring the voids in any aggregate was pointed out and the fact that the volume of the voids was not a true indication of the superficial area of the surface which had to be covered with cementitious material. The point which the author wished to make was that the proportions of the materials should be adjusted analytically rather than empirically, but it appears to the writer that the method of obtaining the densest possible mixture from given aggregates as described in "Notes on Cement and Concrete," Part I, S.M.E., 1923, page 24, is of more practical value than the analytical method of the author.

The second paper, on measurement of Air Supply to Rotary Kilns, was of more interest to the manufacturer than to the user of cements. It was pointed out, however, that the efficiency of the kiln depended on the air supply, and that the cost of manufacture and consequently the cost of the product, depended on the efficiency of the plant and that therefore all engineers should be interested in the methods of manufacture.

The discussion of the third paper was opened by Colonel H. Vaughan Kent, C.B., M.I.C.E., M.I.STRUCT.E., M.AM.SOC.C.E., on his paper, "Concrete Block Construction," and was replied to by Major W. H. Smith, M.I.STRUCT.E., who had also contributed a paper on Concrete Block Buildings. A lively debate ensued on the merits of slab construction *versus* block construction. In the past many concrete houses have been erected, and experience has shown that the following difficulties have to be overcome in small concrete houses. In the first place, to be economically erected the walls have to be comparatively thin; massive walls cannot be used. In thin walls, if a non-absorbent material is used, condensation takes place on the interior walls and the house is damp; if a porous material is used, moisture penetrates from the outside of the walls and the house is still damp. Rendering the exterior face of the wall is expensive and the rendered surface is liable to deteriorate and scale off. Concrete is usually a good conductor of heat, and a house with solid concrete walls is liable to be hot in summer and cold in winter. With concrete laid *in situ* it is difficult to mould hollows in thin walls and, unless different concrete mixtures are used for the exterior and interior faces, damp walls will result for the reasons given above.

Both Colonel Vaughan Kent and Major Smith claim to have overcome all the above defects, and also claim that concrete houses can be constructed which are cheaper, warmer and more comfortable than brick houses.

The Kent system of construction is one of slabs fixed to upright concrete pillars. The method of fixation is ingenious and provides an ample air space between the exterior and interior slabs. *Figs.* 1, 2 and 3 show the method of erection. P is the pillar cast with shoulders, against which the exterior slabs XS abut, at intervals

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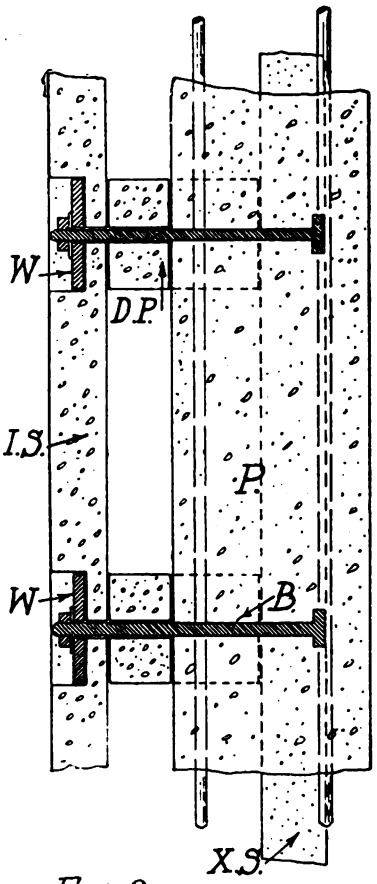


Fig. 2.
(Section a-a.)

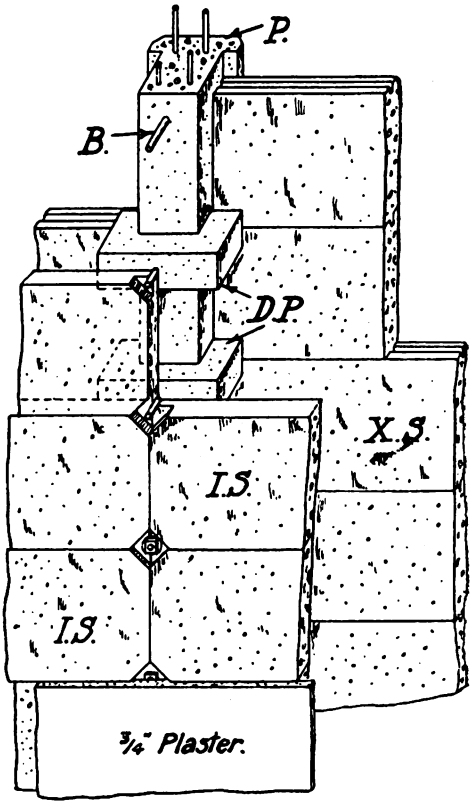


Fig. 3.

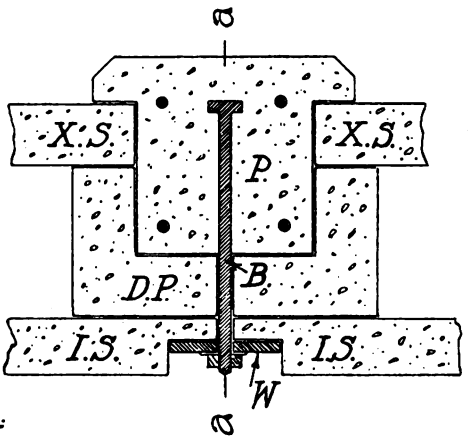


Fig. 1.

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equal to the height of a slab, ½-in. iron bolts B are introduced into the pillar and project inwards in a horizontal direction. DP is a distance piece of damp-proof material which slips over the ½-in. bolts and secures the exterior slab. The interior slabs IS are secured against the distance-piece by means of a washer and nut screwed on to the ½-in. bolt, one washer engaging into corner rebates of four slabs which meet at the bolt. By tightening the nut both the interior and exterior slabs are securely fixed to the pillar. The interior face is plastered, thus concealing the nuts and washers. The exterior slabs are moulded with dense concrete to make them waterproof, whilst the interior slabs are of porous material to prevent condensation. As the distance-pieces are only a few inches wide, the wall cavity is continuous all round the house and may be used for containing service water and gas pipes. Door and window frames are fitted between pillars and are of such a size that they replace a certain number of slabs. Details for fixing roofs, floors, partition walls, etc., have all been worked out by Colonel Kent, and the system has proved perfectly feasible in practice. The advantages are that all units are precast and the erection is very rapid after moulding has been completed. The difficulties appear to be the accurate spacing of the ½-in. bolts in the pillars and the erection of the pillars truly vertical and at the correct intervals, as the margin of permissible error is small.

Major Smith's system consists of the use of triangular hollow concrete blocks, the base of the triangular blocks forming, alternately, the exterior or interior face of the wall. By varying the composition of the blocks, the exterior face of the wall may be made of damp-proof concrete, while the interior face may be made of porous material. The ample cavities in the blocks insulate the walls and save material. These blocks are manufactured in the "Trianco Portable Dual Pressure Double Toggle Machine," marketed by the Triangular Construction Company, Ltd., and claimed to be one of the most efficient block-making machines on the market. It is capable of turning out blocks of any shape and is not limited to the triangular blocks, which, however, can be moulded in this machine more efficiently than in any other. The triangular blocks give a good bond when laid and appear to overcome most of the disadvantages of concrete construction.

A paper contributed by Mr. L. A. Munro, B.A., F.I.C., on Silicate of Soda and Concrete with special reference to the treatment of roads, floors, etc., for the prevention of abrasion and dusting, was of great interest. Messrs. Brunner, Mond and Co., Ltd., have investigated this question very thoroughly, and have placed on the market a particular grade of silicate of soda known as P.84 grade, which they make for the purpose of treating concrete.

The method of application of silicate of soda to concrete surfaces is as follows.

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Although concrete can be made in such a way as to be almost impervious to water, most concrete surfaces in practice are distinctly porous, and it is only by very careful tamping that a layer of wet cement can be brought to the surface to form an impervious skin.

To get the best results from the silicate treatment it is essential that the concrete should be reasonably clean, free from grease, laitance, etc., and should be as dry as possible. The whole process depends on the penetration of the concrete by the silicate of soda. The solution of silicate of soda should be quite dilute, and there is no doubt that many failures have been due to this precaution being neglected. A solution of silicate of soda differs from a solution of, say, common salt, in that the particles of silicate of soda are not really dissolved at all in the ordinary sense of the word, but exist in a state of extremely fine division, generally known as a colloidal solution. Unless the silicate of soda is diluted with several times its volume of water, it will not penetrate into the concrete to the necessary extent.

To get the best results, the concrete should be sprayed with the diluted silicate of soda solution and the latter worked backwards and forwards over the concrete with a soft broom. A hard brush should on no account be used, as particles of sand and cement may be brushed up from the concrete to form a mud, as it were. Most types of concrete will absorb a dilute silicate solution quite rapidly. When the surface has been allowed to dry the process should be repeated, and, although in most cases three such treatments will suffice, low-grade concrete will absorb more than three coats of silicate of soda, and the treatment in such cases should be continued until the concrete ceases to absorb the solution readily. The treatment does not alter the appearance of the surface to any great extent, nor does it render the concrete slippery; in fact, the original rough finish is preserved.

It should be understood that the binding action obtained does not depend upon the adhesive properties of the silicate of soda itself, but upon the products of the reaction which takes place between the silicate and the lime and calcium silicates in the cement.

Various uses of silicate of soda were enumerated as follows:

On factory floors to prevent abrasion and dust. On concrete roads for the same purpose. In this connection Mr. A. L. Thompson, M.R.S.I., M.INST.M. & CY.E., Joint Burgh Surveyor of Motherwell and Wishaw, writing in the "Contractors' Record and Municipal Engineering" of January 16th, 1924, states—"To sum up, on whatever count it may be taken, the treatment of a concrete road with silicates is decidedly advantageous, giving an increased life, raising the resistance to abrasion and disintegration and reducing the formation of dust. The surface is not rendered slippery, nor is it rendered unsuitable for being skinned over with tar. Finally, the cost is

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reasonable, and is justified by the results secured, particularly in the case of the all-concrete road."

On concrete subjected to the action of sea water, the silicate forms a dense skin on the surface and prevents abrasion and the penetration of sea water. On concrete subjected to the action of oil the treatment of the surface with silicate of soda gives good results.

Flat concrete roofs can be rendered waterproof by means of silicate of soda.

The opinion of the Congress was that all these claims should be admitted and that silicate of soda will be extremely helpful under certain circumstances to the engineer.

Messrs. Brunner, Mond and Co. have an abrasion machine demonstrating at the British Empire Exhibition at their stand Section A 55B.

Mr. H. K. G. Bamber, M.I.STRUCT.E., A.INST.C.E., etc., read a paper on "Some Disturbing Factors in Cement Setting." Unless subjected to some treatment during manufacture, all rotary kiln cements would be "flash" setting; various methods are adopted to retard the setting, the usual method being to add gypsum during the grinding process. Although the manufacturer can accurately determine the setting time when the cement leaves the factory, he cannot control action due to long storage or exposure to damp or great heat. After prolonged storage the setting time is usually quickened and therefore it is of importance that the structural engineer should test each batch of stored cement for setting time in order to ensure that he will have sufficient time for mixing and placing before setting commences.

On the other hand cement exposed to the atmosphere for long periods may become so slow setting as to be almost inert.

Aggregates may have an influence on the setting of cements. The author cites a case where an aggregate which appeared under ordinary examination to be suitable in all respects, turned out to be useless with one high-grade Portland cement, and satisfactory with another; both being well-known brands of the highest quality, testing far in excess of the British Standard Specification requirements. Chemical and physical examination failed to detect the disturbing element which, while permitting one cement to set satisfactorily, absolutely destroyed the setting properties of the other, a change of aggregate resulting in both cements being satisfactory. Such an experience is an indication to the structural engineer of the importance of thorough investigation into the character of concrete aggregates proposed to be used before actual work is commenced. It is always advisable to test the aggregates to be employed, especially if not obtained from recognized and approved sources, with the brand of cement intended to be used.

At all times the best results are likely to be obtained by the use

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of slow-setting cement. It is a fallacy to suppose that greater strength is obtained at early dates by the use of moderately quick-setting cements, which are always more liable to be injured if the work is not carried out with the greatest expedition.

In conclusion, the greatest safeguard which the structural engineer possesses is to obtain slow-setting cement from absolutely reliable sources, and, when it comes into his possession or under his supervision, to protect it with all reasonable care against atmospheric influences, regulating his constructional operations so that the time taken for their complete performance is not extended beyond the time when the cement commences to set, which may vary from day to day, depending upon the temperature and hygroscopic condition of the atmosphere.

The paper on "Portland Cement in Sea Water," by F. E. Wentworth-Shields, O.B.E., M.INST.C.E., is of such interest that it is produced below in full.

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"The Committee of the Institution of Civil Engineers appointed to investigate the deterioration of structures exposed to the action of sea water reported *inter alia* in 1920, that 'it is taken by most engineers as definitely determined that properly constituted Portland cement concrete, employed as it should be, may be relied upon to produce sound and permanent work.'

This statement will probably meet with general agreement. But it must not be forgotten that a great many cases have occurred of Portland cement structures suffering considerable damage and deterioration in sea water, and that such structures have been for the most part built with what would be called good materials and careful workmanship. So that, even if we accept the Civil Engineers' conclusion, we are faced with the important question, when is concrete 'properly constituted' for maritime structures, and how should it be employed?

## Instances of Failures.

Though fortunately the successes of concrete in sea water have been more numerous than the failures, there have probably been a fair number of cases of deterioration that most of us have heard nothing about. Some, however, have been carefully investigated and the results published

Mr. J. Mitchell Moncrieff, C.B.E., M.INST.C.E., the well-known harbour engineer, quotes a remarkable case in his paper read at the recent International Navigation Congress. The scene was a graving dock built on the Tyne in 1892. It was apparent from the first that the concrete walls were not watertight, as a number of small leaks appeared at high tide. After a few years it was found that the entrance walls were steadily growing in height, and that gradually

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the anchor rings, which secured the top of the gates, rose until they were almost above the gates; more than once these anchor rings had to be lowered down. In fact, the west wall, which originally was about 27 ft. from floor to cope, actually grew in height to the extent of $6\frac{3}{8}$ ins. in 22 years. The concrete, though originally good and proportioned 1, $1\frac{1}{2}$, $4\frac{1}{2}$, with a richer mixture round the stone quoins, was found to be in poor condition, with the pores filled with a slimy material of no cementitious value. Obviously this was a case where the sea water percolating through the concrete walls into the dry dock attacked the cement, with consequent swelling and softening of the originally hard concrete. Sometimes cases occur where softening of the concrete takes place, but without swelling. In almost all cases of deterioration it is found that the sea water is being forced through the concrete owing to a difference of water-level between the two faces of the structure. It often happens with a well-made concrete that this action is gradually lessened as time goes on by the fact that the white substance formed by the chemical actions chokes the pores of the concrete and thus prevents more sea water passing through it, and arrests the decay. This is what probably takes place in all rich and well proportioned concretes in sea water.

## CHEMICAL EFFECT OF SEA WATER UPON CEMENT.

A very large amount of research work has been carried out, particularly in France and Germany, to determine the exact nature of the chemical effect of sea water upon Portland cement, and also to ascertain how that effect can be rendered harmless. For several years the injurious action of sea water was ascribed to the presence of magnesia, because that element was found in the soft white material formed as a result of that action. But it is now agreed that the trouble is due to sulphuric acid present in sea water in the form of soluble sulphates.

These sulphates combine with the lime which happens to be combined in the cement, or which is freed during the process of setting, to form sulphate of lime. The latter compound combines with the aluminate of lime in the cement and with water to form a double compound which is bulky and non-cementitious. This is the principal chemical action involved (though not the only one) when sea water or other waters containing sulphates disintegrate concretes and mortars made with Portland cement.

## DETERIORATION FROM PHYSICAL CAUSES.

This unfriendly action of sea water upon cement concrete is, of course, greatly aggravated in cases where the structure is exposed to frost and ice, or to the force of heavy waves, or to the attrition of travelling shingle or sand. Frost is probably the worst enemy, and

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concrete which is exposed to tidal waters in arctic regions has to be made exceptionally well to prevent its being disintegrated by the alternate exposure to water and air at low temperatures.

### Prevention of Sea Action by Chemical Devices.

The experts who have studied the question of how to prevent the decomposition of cement concrete and mortars by sea water might be roughly divided into two opposite camps, namely, those who have sought to protect the cement by altering its chemical composition or adding material which should affect the chemical actions involved, and, on the other hand, those who have sought to protect the concrete by preventing the admission of the sea water into the bulk of the material; in other words, by making it highly impermeable.

As regards the chemical school, the earliest and perhaps the most famous was the great French chemist Vicat, although a very large amount of valuable research has been carried out since his time, particularly in France and Germany. Vicat first explained the chemical action of sea water on cement and laid down rules for its composition in order to secure its stability. He pointed out that lime was the most vulnerable ingredient in cement, and that there should be only a sufficient quantity present to combine with the other salts. Since his time many attempts have been made to vary the ingredients so as to produce a cement which would be more permanent. It seems to be generally assumed to-day that cement which complies with the standard specifications of Great Britain and other countries is suitable for use in sea water, but this view is sometimes contested.

Several materials have been suggested as additions to Portland cement for the purpose of increasing its chemical stability in sea water. Of these by far the best known and most used is pozzuolana or trass, which is much favoured by harbour engineers in Europe. It has not been very popular in Great Britain, although Smeaton used it in conjunction with lime to make his mortar for the Eddystone Lighthouse in 1756. Apparently its virtue consists in the fact that it combines with the lime which is freed during the process of setting of Portland cement, and thus prevents the formation of the dangerous sulphate of lime. Although trass occurs in many different places, it is by no means equally suitable for this purpose. A large number of experiments have been carried out at various times and in various countries to show the value of this material. To the general reader they are not always very convincing; but the fact remains that most of the engineers and chemists who have made these experiments are strong advocates of its use. It would seem that other materials, such as blast furnace slag, have a similar power of combining with free lime; and it may be that our latest standard

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specification will encourage the manufacture of a material which will prove to have great durability in marine structures.

A cement which promises to have high powers of resistance to sea action is 'Ciment Fondu,' during the setting of which it is said that no free lime is formed. At all events tests by M. Feret and others seem to show that sulphate of lime has no deleterious effect whatever upon it. Its quick-hardening properties and great strength are beginning to be fairly well known, and if it can be shown that its good qualities can always be relied upon, and that the makers can supply it in sufficient quantity and 'up to sample,' it is likely to become popular among harbour engineers in spite of its high cost.

PREVENTION OF SEA ACTION BY INCREASING IMPERMEABILITY.

There are a large number of experts who consider that modern Portland cement will make a concrete which is very durable in sea water, provided the concrete be made in such a way as to offer a high resistance to the passage of the water into its mass. If the concrete is highly impermeable it is claimed that what little sea water does penetrate can do no harm, as the solid products of the chemical action involved tend to choke up the pores of the concrete and make it the more impermeable. Whereas in the case of a porous concrete the products get washed out, leaving fresh surfaces to be attacked by a fresh supply of sea water.

It is well to bear in mind that there is no such thing as an absolutely impermeable concrete. All one can hope to do is to reduce the size and proportion of voids and thus to make the resistance to the passage of sea water as great as possible. But this is by no means as easy as it sounds, and although some fine research work has been carried out on the subject, particularly in France and America, the matter calls for still further investigation. We have, however, at least certain conclusions on the matter. First, the mixture must be rich in cement. Any concrete containing mortar poorer than 1·2 is likely to be useless in cases where sea action is feared. The stones and sand should be well graded, *i.e.*, they should vary in size from coarse to fine, and at all costs a large proportion of fine sand is to be avoided. The concrete should be well mixed by a good machine. The proportion of water should be carefully determined, as either an excess or defect of water when gauging is liable to produce porous concrete. Pouring concrete under water should be avoided, as concrete moulded in this way is of doubtful quality and very permeable.

It has been suggested that denser concretes can be produced by special cements, but the writer has met with no experiments which are conclusive on this point. Again, many materials are on the market for which it is claimed that, if mixed with concrete or mortar, they greatly decrease its permeability. An elaborate investigation was made into a number of such materials by the American Bureau of

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Standards in 1911. It tended to show that the addition of such materials was of little use in the case of rich mixtures and that some of them decreased the strength of the mortar.

We are still in want of a really good test for impermeability. Several methods have been used, such as determining the actual volumes of materials used in a cubic unit of concrete, and hence the proportion of voids, or again, measuring the quantity of water which can be forced into or through a slab of known dimensions in a unit of time. But these methods are slow, and do not tell exactly what is wanted. If we could test for permeability as easily as we can test for strength, and compare that test with a standard, it would not be long before we should all be able to use our various materials to make a concrete which would offer the greatest possible resistance to the destructive action of sea water."

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Three papers concerning the Manufacture of Portland Cement and Research were contributed, but as these were not of great interest to the structural engineer they may be passed over.

One remark by Mr. Thaddeus Merriman, Chief Engineer Board of Water Supply, City of New York, is of interest. He states that, notwithstanding the great improvements and developments which have taken place recently in the methods of manufacture, there has been no substantial change in the inherent characteristics of the cement itself since it was first produced. No new cements have been announced until quite recently, as in the case of those based on a high alumina content. It is a surprising commentary that in such an important field of endeavour so relatively little positive advance in definite and specific knowledge should have been made. It is inevitable that a better cement will appear and displace that which now dominates the markets of the world. The natural cement of 1890 gave way to the Portland cement of to-day. In like manner will Portland cement yield its high position to some yet unknown successor? The natural laws of progress and development are not to be denied.

In his paper on Structural Steelwork Reinforced with Concrete, Mr. Ewart S. Andrews, B.SC., M.I.STRUCT.E., A.M.INST.C.E., drew attention to the results of experimental tests carried out in the United States and in Canada on the strength of structural steel columns and beams encased in concrete. In each case the strength was increased from 50 to 80 per cent. over that of the plain steel members. Although admittedly this is not an economical method of using steel in reinforced concrete, it offers many advantages in rapid construction, and in the case of a shortage of steel sections allows weaker members to be used to carry the required load. If in a steel structure the steel members are made sufficiently strong to support the dead

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weight of the structure and the necessary centering, the skeleton can be in the process of erection while the lower portions are being concreted. The centering can be supported on the existing steel work and there is no waste of time in setting the reinforcement bars. Economies can also be effected in the centering, as it can be removed at an earlier date, the steel member taking the weight of the concrete which is not subjected to undue stresses before properly set.

Three papers on aluminous cements were presented; the one by M. T. J. Gueritte, B.SC., M.S.I.C.F., M.I.STRUCT.E., gave some interesting results.

The following results of tests give a good idea of the strengths obtained by use of good aluminous cement. These tests were carried out in many different testing laboratories, and the personal equation of individual tests thereby eliminated from the results.

TABLE 1.

Neat Cement.—In lbs. per square in.

| Time. | 1 day. | 2 days. | 3 days. | 7 days. | 28 days. | 12 wks. |
|---|---|---|---|---|---|---|
| Tension : | | | | | | |
| Average ... | 627 | 833 | 877 | 895 | 1027 | 1360 |
| Maximum ... | 730 | 981 | 915 | 1033 | 1060 | 1382 |
| Compression : | | | | | | |
| Average ... | 6733 | 7739 | 9340 | 9596 | 12125 | |
| Maximum ... | 7037 | 9766 | 10560 | 11586 | 13700 | |
| Ratio between compression and tension | 10·74 | 9·29 | 10·65 | 10·72 | 11·8 | |

TABLE 2.

Cement and Sand.—1 : 3. In lbs. per square in.

| Time. | 1 day. | 2 days. | 3 days. | 7 days. | 28 days. | 12 wks. |
|---|---|---|---|---|---|---|
| Tension : | | | | | | |
| Average ... ... | 331 | 427 | 455 | 518 | 551 | 632 |
| Maximum ... | 412 | 526 | 560 | 593 | 692 | 691 |
| Compression : | | | | | | |
| Average ... ... | 3528 | 5166 | 5456 | 5893 | 6671 | 8900 |
| Maximum ... | 5000 | 5230 | 6870 | 6150 | 7300 | 9008 |
| Ratio between compression and tension | 10·65 | 12·09 | 11·99 | 11·37 | 12·10 | 14·08 |

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Tests over long periods of time are now available, carried out at the Laboratoire National des Ponts et Chaussées, Paris.

The proportions used were 1 cement, 1 sand, 3 gravel (by volume) and the crushing strengths in lbs. per square inch were as follows :—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 days | ... | ... | ... | 6013 lbs. | per | square | inch |
| 7 days | ... | ... | ... | 6212 | ,, | ,, | ,, |
| 28 days | ... | ... | ... | 7690 | ,, | ,, | ,, |
| 3 months | | ... | ... | 8345 | ,, | ,, | ,, |
| 6 months | | ... | ... | 8900 | ,, | ,, | ,, |
| 1 year | ... | ... | ... | 9354 | ,, | ,, | ,, |
| 2 years | ... | ... | ... | 9482 | ,, | ,, | ,, |
| 5 years | ... | ... | ... | 9695 | ,, | ,, | ,, |

It was pointed out that the working stresses allowed for Portland cement concrete by the L.C.C. rules for 4 : 2 : 1 concrete is 600 lbs. per sq. inch, but the author considered that working stresses from 1,300 to 1,400 lbs. per sq. inch for aluminous cement concrete of the same proportions would give the same factor of safety.

Stress was laid on the necessity for careful mixing, laying and curing of aluminous cement concrete, and the following rules should be followed when using it :—

(1) A clean concrete mixer, or mixing platform, and conveying skips, landing boards, shovels, rammers, etc., entirely free from Portland cement or dirt.

(2) A thorough intimate mixing in the mixer or on the mixing platform. In practice about twice (some people even say thrice) as much mixing as for Portland cement, this owing probably to the very great fineness to which Bauxite cement is ground. Too great importance cannot be attached to this point.

(3) Sand and aggregate of excellent quality, very clean and well graded. A slight excess of sand seems to be better than a deficiency : sharp sand gives decidedly better results than fine or soft sand.

(4) The concrete should be mixed just slightly wetter than Portland concrete. With aggregate and sand, containing a normal amount of moisture, good results have been obtained by using from 33 to 35 gallons of water for 1 cubic yard of $\frac{3}{4}$-in. gravel, $13\frac{1}{2}$ cubic feet of sand and $6\frac{3}{4}$ cubic feet of cement. An excess of water has a much more lowering effect upon the strength of aluminous concrete than on that of Portland concrete. (For figures on that point, see the author's remarks in the *Institution of Structural Engineers' Journal*, September, 1923, page 266, column 2.) Trouble has arisen occasionally because new users tried to secure the same plas-

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ticity as with Portland cement, without taking greater pains in ramming, by using an excess of water. It is not water that is required so much as thorough mixing and thorough ramming.

(5) Water thoroughly the shuttering and steel with fresh water before depositing the concrete. But, as water washes away the cement easily from the aggregate and sand, take care: (*a*) Not to leave water in the mould; (*b*) to use fairly water-tight shuttering; (*c*) to prevent external water from coming in touch with the concrete until the latter has "set off."

(6) Careful and intense ramming during placing of concrete. This again is extremely important.

(7) Immediately after the concrete "sets off," water the concrete freely at frequent intervals for a few hours, and keep on watering from time to time for a few days, or cover the concrete with a layer of sand kept wet, so that the concrete remains moist. This will prevent the water added during mixing, and which is necessary for the purpose of hydration, from evaporating, first through natural evaporation, and later (from the fifth hour onward) owing to the heat generated during the setting. Such heat will also be reduced thereby.

Aluminous cement concrete is immune from attacks by sea water or sulphurous waters. Its behaviour is more satisfactory than Portland cement concrete when exposed to action of oils. Petroleum oils and tar oils have no effect on it, and under the action of vegetable oils it will remain intact under circumstances which will cause Portland cement concrete to disintegrate.

From a military point of view the great advantages of aluminous cements appear to be, firstly, the long quiescent period after gauging with water before the initial set takes place; this period is from 3 to 4 hours, and would enable concrete to be mixed under good supervision in rear of the trenches and carried forward and placed in front line works without deterioration. The second advantage is its rapid gain of strength; works constructed one day can be taken into use the day following, if essential. Still another advantage is the fact that aluminous cements can be used in frosty weather. Provided that the sand and aggregate used are above 32° F., the heat developed in the setting of aluminous cement will raise the temperature of the mass of concrete sufficiently to prevent any freezing even in very severe weather.

The chief difficulty at present with aluminous cements is to find sufficient raw material, "Bauxite," to enable the manufacturers to meet the ever-increasing demand.

The second day of the Congress was occupied with a visit to the Kent Portland Cement Works near Dartford. This plant is one of

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the most up-to-date plants in England, with an output of 4,500 tons a week of Portland cement.

The delegates were the guests of the Directors of the Associated Portland Cement Manufacturers, Limited, and were conveyed from London Bridge to the works in a launch. An incident on the journey down the river impressed on the delegates the great demand for Portland Cement in this country. In order to replace a broken valve on a wireless installation on board the steam launch, a vessel unloading a cargo in the river was approached; this vessel proved to be an Italian ship offloading a cargo of Italian cement for use in this country, much to the amusement of the guests of the directors of the A.P.C.M.

It is not considered necessary to describe the works visited, as a description of modern cement works has appeared in the March number of the *R.E. Journal*, and although there were a few differences in the detail of the processes, the general principles were the same. One was very much impressed by the small number of men employed on the works, all materials being handled automatically as far as possible. To produce 4,500 tons of cement weekly, about 9,000 tons of raw material has to be handled and the best organization is required to do this efficiently and economically.

On the third day the delegates were the guests of the Institution of Structural Engineers at the British Empire Exhibition. Here one saw the latest examples of reinforced concrete structural engineering in the Stadium and the Palaces of Engineering and Industry. These buildings, however, have frequently been described in many engineering journals, and it is unnecessary to enter into a detailed description of them here.

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# *A PLEA FOR A STRONG ANTI-AIRCRAFT DEFENCE.*

*By* LIEUT.-COLONEL D. M. F. HOYSTED, D.S.O., R.E.

IT is a trite opinion, almost universally accepted, that the opening move in a future war between great powers will begin with a surprise blow dealt from the air with great concentration. In its application to these islands this opening attack will have a twofold object. Firstly, that of putting our naval and aerial forces out of commission before they can leave their stations ; and secondly, of terrorizing the inhabitants as well as the defenders of the invaded territory. The last war was a crucial test of nerve, but the next will be far more trying.

The controversy as to the relative merits of aircraft and surface ships on the open sea is being thoroughly tested by the United States as well as ourselves ; the ultimate outcome is still obscure. Aircraft enthusiasts declare that they have driven the Navy from the surface, while the Navy denies the aspersion with no little warmth. Be the result as it may, the initial process mentioned above is now generally accepted as a probability. Bombing planes will be able to bomb naval defences and ships in harbour as easily as a battleship could shell them, while the faster type of plane will be used in the place of cruisers and destroyers for minor raids and attacks on shipping or unfortified towns and factories. These bombing planes will be protected by fighters and will be able to operate from a base some 250 miles from their objective. The day of the bombing airship is practically over, as such craft are too uncertain and unwieldy for use in large concentrations: the Allies backed the winning horse before 1914 and the German Zeppelin was beaten before the war began.

So far, the starting-point for such an attack has been a land base, and if a line were drawn parallel to the eastern and southern coastline of these islands and at a distance of 250 miles, it would enclose any land area from which it would be possible to deliver the attack. More definite information as to the actual position of such a base will be gathered from the political situation of the moment.

So much for the land base, but what of the sea base ? For aircraft can operate as easily over water as over land. So that in the future the blow may originate from either a land base or a sea base, or both, according to its aim and the situation of the objective. As a naval

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power it behoves us to consider the possibilities to which we might at any time be open.

Let us think for a moment of the possibilities of a temporary base on the water. Article VII of the Agreement for Limitation of Armaments lays down a total tonnage for aircraft carriers for the British Empire of 135,000 tons; United States 135,000 tons, Japan 81,000 tons, France 60,000 tons, Italy 60,000 tons. Moreover, no aircraft carrier may exceed 27,000 tons displacement. The gun-power of an aircraft carrier is limited, though the number of anti-aircraft guns is unlimited. Our aircraft carriers have a capacity of 25 planes for 10,000 tons of displacement, or two and a half per 1,000 tons. Probably, in future ships, the ratio will rise to three planes per 1,000 tons of displacement, if not more. Even at that percentage, the tonnage allowed us by the Agreement could produce 405 aeroplanes on properly equipped carriers at any given moment at any desired spot in the Seven Seas.

The aircraft carrier is provided with facilities for both launching and landing. The former requirement is met by catapults and other devices, the latter by shock and momentum absorbers, such as nets, springs or rubber ropes on a specially prepared deck. Such aircraft could probably be launched into the air at the rate of about one every five minutes from each ship. From nine carriers, each of 15,000 tons, making up the total displacement at present authorized for the United States, nine aeroplanes could take wing every five minutes, or, say, one hundred an hour for four hours. In addition to the authorized aircraft carriers, an attacking sea base would no doubt include an establishment of spare planes on special store tender ships, so as to be in a position to make up for wastage. There is no limit to the number of these tenders which can carry planes of all sorts.

So far we have only visualized a law-abiding foe who feels himself bound by the international instrument above-mentioned. But he will not necessarily allow himself to be fettered at the outset by a written covenant merely because he has solemnly signed on his honour to abide by it. He can quote a precedent. He will realize that he must meet a brave and efficient association of nations and will naturally wait till he has perfected in secret all the requirements that a scientifically trained staff can foresee. For instance, large ocean-going submarine seaplane carriers are no more fantastic, than the prophetic *Nautilus* and *Clipper of the Clouds* described by Jules Verne so many years before their time.

In the past, successful surprise raids were more easily carried out from the sea than from the land, because preparation could be concealed and traces destroyed: how much more so will they be possible by air?

Previous to 1914 a great attack on the United Kingdom must have

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been preceded by superiority at sea, temporary and local though it might be ; even Napoleon conceded this point. Under present conditions, as the radius of efficiency of aircraft increases, great superiority in the air will be advantage enough, and it will be much cheaper to obtain. In the day of hostile superiority in the air and in the face of constant attack from ever-changing bases, the concentration of the Grand Fleet at Scapa Flow for such a length of time would be impossible, and even land mobilization would be greatly disorganized.

This threat of a smothering offensive from the clouds is so imperative and conclusive as to warrant the greatest efforts for the provision of men, money and material to ensure an adequate defence against it by the time it reaches its danger-point. Our counter-effort must be built upon efficient information and a rightly-conceived defensive power. By the nature of things the invention of the offensive weapon must needs precede the design of the countervailing system of defence. The sword preceded the shield. An adequate defence to counter any process of attack will always be produced eventually. The sole question for the defence is, to speed up the new invention so that the period during which that special engine of attack can reign supreme may be reduced to a minimum.

The defence against aerial attack at present consists of aircraft, searchlights, guns on special mountings and sound locators, not forgetting electrical communications and camouflage. There are several other possibilities in the future which will be developed in due course as surely as was the shield and the A.A. gun. At present electrical communications and sound locators must supply the requisite information and the guns, searchlights and aircraft the efficient defence. Sound locators will doubtless become more sensitive and accurate and their intimate connection with the searching beam will become automatic and assured, while gunfire will be more accurate and intense.

But one of the great lessons which the warfare of the past should have taught us regarding warfare of the future, embraces the fact that if the defence at the outset of hostilities does not hold up the attack, the attack will overwhelm the defence : there is no possibility of stalemate in the air. As a nation we seem to have been consistently unprepared for our wars. The sea has been our first defence, and, with our " standing luck " or our national character, it has always enabled us to make up for unpreparedness, so far ; but——?

If there should be such an attack on the Empire, where will the blow fall? An overwhelming attempt on either Canada, Australia or any other outlying member of the family, would certainly have but the effect of sending such a thrill through the others as would solely result in cementing them more firmly together and bracing up their spirits to fight it out to the last man and the last shilling. To

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obtain the best strategic result, the blow should fall not only on these islands, but on the southern portions of Great Britain, the centre of the web. Naturally, therefore, the major part of the defences of the Empire must be based upon Great Britain. The principal nerve centres to be defended from aerial attack are the large harbours and anchorages, barracks, ammunition depôts, the factories of warlike stores and the great cities and towns of England where Bolshevik upheaval might be hoped for by the enemy.

Aerial attacks on inland objectives will generally be carried out in formation by night. Formation flying is imperative in order that the units may not foul each other, especially in a large concentration, and that they may be able to keep up the necessary rain of bombs on the required target. The approach of a formation by night is always made along some route which may be easily picked up in the dark, and which will present some definite and recognizable landmarks, such as the edge of sea-shores or lakes, a river, railway-line or main road.

Though the best defence against aircraft is furnished by aircraft, the other defensive elements on the ground have much the same effect as field fortifications in a land war of movement. In addition to the actual losses they cause, they render it possible to concentrate the main force at the point where it can produce the most telling result. As barbed wire provides the quickest and most effective means of denying ground to a land enemy, so aerial impediments have afforded the most effective way, so far, of denying certain avenues of approach by night to hostile air-raiders. They have one great advantage over barbed wire. They are not immovably fixed to their site, but can be moved about as required so that they combine the element of surprise which is so harassing to the airman's nerves. Other means are also in course of production. In this manner the most probable lines of approach to a target such as has been enumerated can be made extremely difficult by raising across it some such obstruction. For if a flying formation is once broken up at night, it loses at once its greatest asset for successful service, if not its actual existence.

In the past an attacking navy had the power of suddenly concentrating a superiority of gun-fire against its objective and for this reason coast fortifications had to be scattered so as to be ready to take up the challenge instantly wherever it might be flung, and to hold the line till reserves could be brought up to neutralize the superiority due to surprise. In the future the attacking air force will have similar power, and therefore, for a like reason, anti-aircraft defences must be dispersed and in position round the key-points, as the period of warning will be shorter than ever. Successful raids would otherwise be the rule and not the exception.

But a strong enough anti-aircraft defence would confound the

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tactics of the enemy by leaving the active air squadrons free to defeat him strategically. Even if the defender's air force is strong, compared to that of the opponent, an adequate anti-aircraft defence will ensure economy of force and enable the defender's active air units to be used to the best advantage irrespective of the attack. But when the defender's air force is weak, a supreme anti-aircraft defence is an imperative necessity as an insurance against annihilation.

In the period before the last war, our degree of necessary preparedness was assumed to be less than that of a great continental power because of our insular position and the value of sea power. Now the difference, as far as aerial warfare is concerned, is entirely eliminated and we stand exactly the same danger from an overwhelming lightning stroke as did our allies of 1914. We should, therefore, see that the training and equipment of our anti-aircraft measures shall be the most efficient in the world, so that, if called upon in the future, our defence may prove itself as potent as before. To set the foundation stone to this, it is necessary to plan in detail our anti-aircraft policy and the positions of all its component parts. But it is only by completion of at least one entire section of the defences in every detail that the test for the ultimate limit of efficiency can be applied to it, so as to find the weakness and enable experts to work out the remedy.

Whenever a new means of warfare has been produced, a certain period of time must necessarily elapse before the best means of co-operation with the other arms can be worked out to a satisfactory conclusion. How will it affect strategy or tactics? What modifications will it necessitate for other branches or services? What changes of establishment will it induce?

These vital questions can only be answered by selecting a certain important area for experimental purposes and then by working out the application and technique of the means now coming to fruition. First, the application of the ever-true principles of strategy in making the estimate, *i.e.*, the objective, the difficulties to be overcome, the resources at our disposal and the plan, and when that has been completed on the ground, the application of the breaking test.

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# *THE DECISION TO DEFEND KUT-EL-AMARAH.*

*By* MAJOR E. W. C. SANDES, D.S.O., M.C., R.E.

A SMALL boat, with a picked crew and an expert steersman, once put to sea in fine but threatening weather. She was safely launched, and rode undamaged through several lines of breakers, being handled with daring and skill, so that at last only one line foamed and spouted ahead of her. But the tide was already on the turn, and a storm was brewing, so the steersman hesitated to make the attempt which would bring him to the open sea. In the end he made a dash for the last line of breakers, hoping to get through at the first attempt and relying on the proved courage and grit of his men, but the waves checked the boat, and the incoming tide gradually brought her to a standstill. The exhausted crew battled furiously to make headway. Two men were swept overboard, and the boat was almost swamped and began to leak, so the steersman decided to make for harbour. He managed to turn between two waves and ran for home. The storm roared behind him and his boat was sinking, but he saw a sandbank and grounded her under its lee, intending to rest his crew and repair the boat while the storm lasted, and then to try again. He forgot the tide. It rose slowly, and finally engulfed him and his men within sight of their friends on shore, many of whom perished in attempts to reach the castaways.

This allegory represents, in some ways, the case of the late General Sir Charles Townshend and his force in the attempt to capture Baghdad in 1916, and his retreat to, and surrender at, Kut-el-Amarah. The 6th Indian Division was a highly trained force, and its commander a skilful strategist and tactician who had the complete confidence of his men. The boat was launched at Basra, she forced a passage through the breakers at Kurna and again at Kut, and her commander hesitated before the waves below Baghdad but decided to make the attempt. The tide of Turkish reinforcements from the north checked his small craft, and, with a reduced and exhausted crew, he managed to turn his leaking boat and reach the island of Kut. There the tide of the enemy gradually overwhelmed him within a few miles of the relief force which battled so desperately to reach him through the stormy seas which separated them. The allegory fails in one respect, in that General Townshend's idea in remaining in Kut was not only to rest and save his men but to

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check the advancing foe; but, just as King Canute found that a tide cannot be checked, so Townshend found that the enemy encircled him and soon passed far beyond the limits which he had anticipated when he halted.

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It was in November, 1915, that the 6th Indian Division, with the 30th Brigade and a few other attached troops, gained a partial success over the Turks at Ctesiphon. The Turks, however, were strongly reinforced during and after the fight, and the British force, under Townshend, suffered such casualties that it was compelled to retire a distance of 100 miles to Kut-el-Amarah, pursued by large bodies of the enemy which had arrived from Erzerum and elsewhere. General Townshend's force of about 10,000 men, including roughly 6,000 infantry, was harassed in the retreat by the advanced guard of the Turkish army under Nur-ed-din Pasha, and that advanced guard was superior to it in numbers, and even in armament. The Turkish force was composed of the best Anatolian troops, elated by the retreat of the hitherto victorious British, and guided by the advice and experience of a large staff of German officers. The British, nevertheless, defeated the Turkish advanced guard at Ummal Tabul during the retreat, and thus enabled most of their shipping to reach Kut. This action checked the enemy sufficiently to give Townshend a few days at Kut, prior to the arrival of the enemy, in which to begin to entrench.

The troops, however, were terribly exhausted—so exhausted that, on reaching Kut on the 3rd December, 1915, they were quite incapable of constructing in a few days a complete system of trenches and redoubts for defence against the advancing hordes of the Turks. Rest was imperative, and the question was whether rest could be obtained. It was partly the necessity for rest and reorganization for his retreating force which caused General Townshend to halt at Kut on the 3rd December, 1915. He had not decided till that date, whether he would remain in Kut or not. To quote his own words: "It was practically impossible for me to retire from Kut. So exhausted were my troops that they lay down and could do nothing but eat and sleep for two days." The human factor, then, became an important one in the situation, as it does so often in actual warfare, and the halt of the British force enabled the Turks to regain touch with it after it had outdistanced their pursuing troops in a series of forced marches.

I have given a brief *résumé* of the operations leading up to General Townshend's arrival in Kut from Ctesiphon as it is necessary to visualize clearly the circumstances under which he was forced to decide whether he would halt at Kut and subsequently continue his retreat, or whether he would remain in Kut and defend it against the advancing enemy. I think that any officer who took part in

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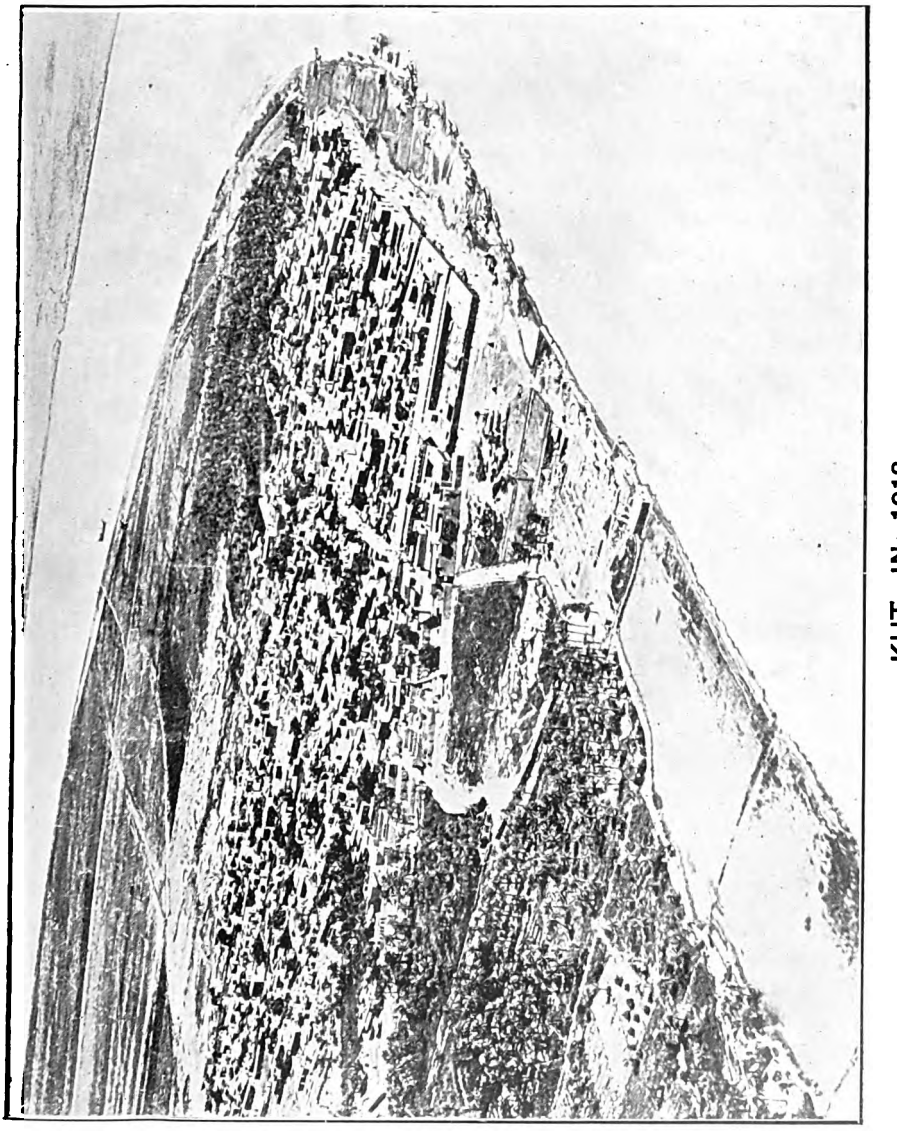

KUT IN 1918.

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the retreat will agree that, whether Kut was held or not, a *halt* at Kut was imperative. The marvel is that the British force ever reached Kut. I do not think that it would have done so if the pursuit had been pushed with vigour and in a scientific and efficient manner. Fortunately, the Turks still had a wholesome respect for our offensive powers, and the Turkish leaders made several gross tactical blunders which prevented our retreat from being cut off.

*Field Service Regulations*, Volume II, Chapter XI, which deals with the subject of " Defence," gives the following axiom :—" When a commander decides to adopt a defensive rôle, the manner in which he will be able to carry out his plan will depend largely upon the time available for preparing his defensive organization, and upon the general situation in the theatre of war. Thus circumstances may only allow of a hastily organized defence, or they may permit of the deliberate occupation of a well-organized defensive position *commanding a line of advance which is essential to the enemy.*" The line of the River Tigris was essential to the advance of the Turks, though the Kut peninsula was not a well-organized defensive position. The fact that the line of the Tigris was essential to the enemy, if he desired to advance any considerable distance into Lower Mesopotamia, was the main point which decided General Townshend to establish himself at Kut. By remaining there until relieved he also denied to the Turks the use of the Shatt-al-Hai Channel leading to Nasariyeh, which might have enabled them to advance on Basra or Amarah, by a flank attack from the west, when that channel filled with water early in January.

On the 3rd December, 1915, General Townshend decided not only to halt at Kut but also to *remain* in Kut, and he informed the Army Commander, General Sir John Nixon, to that effect. So momentous a decision, in a minor theatre of war, has rarely been taken by a subordinate officer. The responsibility of making that decision was left to General Townshend by the Army Commander, who, however, on the 4th December, gave him seven arguments in favour of defending Kut and notified his approval of the decision. In his own opinion General Townshend was forced, in the first instance, to decide between the possible loss of his Division and the probable loss of Mesopotamia. Can one wonder that, maintaining the tradition of offensive action so dear to the British Army, he decided to fight and to risk the loss of his force rather than to retire and perhaps lose the country which he had conquered ? That he did actually lose his force, and that more than 20,000 men were sacrificed in vain endeavours to save that force, was decreed by fate ; yet, if it was a mistake to defend Kut, his action should not be judged without a full consideration of the circumstances which induced him to make his decision. Let us consider those circumstances.

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Firstly, the British force was exhausted on reaching Kut. It could retreat no further, though in a few days it might be able to do so. It was accordingly tied to Kut for, say, three or four days.

Secondly, if it remained in Kut and fortified that locality, it blocked not only the River Tigris to the enemy's shipping, but would also deny the Shatt-al-Hai channel to that shipping when the channel became flooded. The Turks had only five ships upstream of Kut, and they depended on those ships for their ammunition and equipment, and to some extent for their reinforcements and food, though they could live on the land as no British force could. They could not carry the war far into Lower Mesopotamia if Kut was held. They had not sufficient land transport to maintain a large army advancing further and further into a pestilential region, even though the Arabs of that region might be friendly while success attended the Turkish advance. While Kut was held, the Turks were tied to it by a string of a certain length—not by a piece of elastic. If too much strain came on the string it would break ; it would not stretch.

Again, General Townshend was fully aware that reinforcements were only dribbling into Mesopotamia and were a long way off. He was informed on the 5th December, two days after his arrival, that he might count on being relieved in two months, and that a force was being concentrated as soon as possible at Amarah, more than 100 miles away to the south-east, with a covering force of only one brigade at Ali-al-Gharbi, 30 miles to the east. Note the words "as soon as possible." Townshend could not hope to be *adequately* reinforced at Ali-al-Gharbi if he retreated from Kut. He might meet reinforcements before he reached Amarah. But could he reach Amarah, harassed by thousands of Arabs, and possibly pursued in time by large bodies of the best Turkish troops? It seemed problematical at the time. Those who had seen the force enter Kut on the 3rd December might not even have conceded that it was problematical. General Townshend decided that his reinforcements were not sufficiently near him to warrant a further long retreat in an endeavour to meet them. He decided to await their close approach and then to co-operate with them. He was exhausted. They would be comparatively fresh.

The British force was small—about 7,000 infantry. Supposing that a prolonged retreat was impossible, the question arose as to whether this small force could take up a position where it could reasonably expect to withstand the Turkish onslaught for a time, preparatory to further retirement towards its reinforcements. It had very few machine-guns, and little modern artillery except for three batteries of 18-pounders ; therefore it could not occupy an extended line. It had not much barbed wire, and no bombs. For defence it had chiefly to rely on rifle fire. Was there a position of, say, not more than two miles in length where its flanks would be

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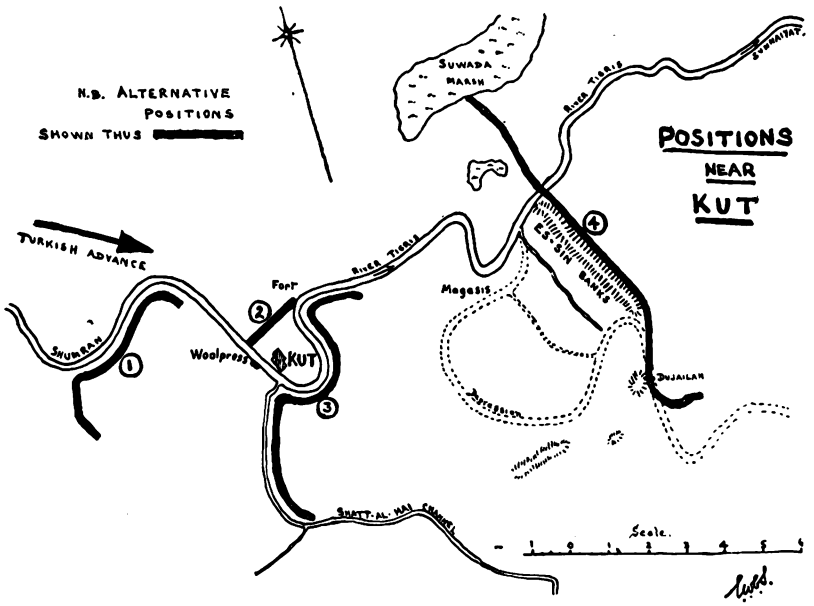
secure? Yes. A position across the neck of land forming the loop of the river Tigris containing Kut would fulfil those conditions. It has been said that General Townshend should have retired to the Es-Sin position, a line of embankment some seven miles below Kut town, where trenches existed. That position was six miles long on the right bank of the Tigris and three miles long on the left bank. The trenches also faced the wrong way. Possibly an Army Corps with plentiful machine-guns might have been able to hold Es-Sin and to protect its flanks from envelopment, but certainly not a force of four weak brigades. Supposing that General Townshend had retired to the Es-Sin position, how long could he have maintained his force there? There were no supplies in the position. There was no transport to bring sufficient quantities of provisions and ammunition from Kut to the position if it was to be held for a week or more. There was no water at Es-Sin except near the river. Amarah was the nearest point from which supplies could be obtained from downstream. General Townshend subsequently wrote as follows:—" Had I taken up my position at Es-Sin, I should have been enveloped and overwhelmed in a decisive battle in three or four days' time." Was there, then, any other position which the British force might have occupied for a time preparatory to retirement? If it could have crossed to the right bank of the Tigris it might have taken up a position on that bank near Shumrān, four miles above Kut, placing the Tigris between it and the enemy owing to a bend in the river, and with its left flank only exposed to envelopment if the Turks crossed to the right bank. This they

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could not do at once as they had no bridge. On the other hand, we had a Bridging Train and I think that I could have constructed a bridge for the crossing of our force, though not at Kut itself. This Shumrān position was recommended by the Brigadier-General, R.E., and a further retirement could have been executed from it to the Shatt-al-Hai channel which could have been held temporarily as a rear position; but the occupation of the Shumrān position would have meant the abandonment of the left bank of the Tigris and of Kut town with all its supplies, and a subsequent retreat under fire from Kut on the flank. Also, we could not have taken sufficient supplies to the position for more than a few days.

General Townshend decided that the only locality in which he could put up a defence, and also maintain his force for a reasonable time, was in the loop of Kut. Here he was secure. His flanks were safe, his rear was safe, he could hold his front line against determined attacks, and, as *Field Service Regulations* put it, "He commanded a line of advance essential to the enemy." He has been criticized for adopting an attitude of passive defence. That was not his intention. To quote his own words once more: "I intended to use my entrenched camp as a pivot of manœuvre, when, by improvising a bridge and a fortified bridgehead, I should be able to throw the principal mass of my force on to either bank of the Tigris in an offensive against an isolated fraction of the enemy. Had my troops been able to work and get the bridge across the Tigris opposite the town of Kut, I should have been able to make an *active* defence." General Townshend was well aware of the usual fate of a force which shuts itself into an entrenched camp for a passive defence. The outstanding example of Marshal Bazaine at Metz in the Franco-Prussian war was ever in his mind. But his plans for an active defence were stultified by a lack of engineering information, and in this respect I should like to indicate how important is the question of the *liaison* of the General Staff with the engineers. A bridge across the Tigris opposite Kut was impossible. I commanded the Bridging Train and had lost most of my boats and all my pontoons during the retreat from Ctesiphon when we were chased by cavalry and had no escort. The river was 600 yards wide opposite Kut town, and I could have told the G.O.C. at once that the maximum length of bridge which I could construct, given several days to do so, was, roughly, 300 yards. If General Townshend had been aware that his system of active defence was thus rendered impossible, he might have altered his decision to remain in the loop of Kut. But he apparently assumed also that he could prevent the Turks from bombarding any bridge with artillery. A large bridge cannot be maintained for more than a few days under hostile artillery fire without great reserves of material and boats, and we had no such reserves of a suitable nature. If a bridge had been constructed it

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would infallibly have been destroyed by the Turkish artillery or mines, or captured by a determined assault, and the defence of Kut would then have become passive, at least, as regards the right bank of the Tigris. On the Kut side, *i.e.*, the left bank, the Turks quickly surrounded our entrenched system with three lines of trenches, well wired, strengthened by redoubts, and supported by artillery. Sorties in force on this bank soon became difficult, and later impossible, owing to the flooded ground. Again, it would seem certain that the intended active defence was doomed to develop into a passive one. However, the Kut loop was considered to be the only possible defensive locality, and it was occupied and strengthened as far as our men were able. The land front to be defended was $1\frac{1}{4}$ miles long and the river protected the flanks and rear. The Turks were in front and the river behind; in fact, we were between the devil and the deep sea.

Another point influencing the decision to defend Kut was that it was our advanced base for supplies, stores and ammunition. These had been accumulated for weeks. The shipping downstream was fully employed in bringing up reinforcements and could bring no more stores. The enemy was naturally short of supplies and would benefit greatly by the recapture of Kut. It was therefore of great importance to preserve our supplies and also our store of ammunition. There was not sufficient transport to remove the bulk of the supplies and stores if we evacuated Kut. On the other hand, the supplies would enable us to withstand a siege of some duration—at any rate, as long a siege as then seemed likely.

However undesirable they may be, political considerations are apt to influence military operations. Kut was no exception. The Political Department was emphatic regarding the bad political effect which would be produced throughout Mesopotamia by a further retirement downstream. The Political Officer pointed out that in such an event our half-hearted Arab allies would go over to the Turks, the country would rise against us, and our prestige would be gone. Also, the failure of the Gallipoli campaign, and the situation in Persia and Afghanistan, made it advisable to avoid the bad effect of a lengthy retirement towards Amarah. Again, when General Townshend had decided to remain in Kut and wished to evacuate all the 6,000 Arabs in the town, he was advised politically that the death of the Arab women and children in the desert, which would probably result from this evacuation, would be a cause of renewed hatred against us, and so most of the Arabs were allowed to remain in Kut where they did little work and ate a vast amount of food. The necessity of maintaining British prestige in Mesopotamia thus influenced General Townshend in reaching his decision to retire no further than Kut, and certainly shortened the

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period of resistance of which the garrison was capable when surrounded by the Turks.

The Russians under General Baratoff were demonstrating towards Baghdad from Persia, and it was advisable to co-operate with them. By holding a large Turkish force at Kut the British assisted their allies from Russia. The Russian force, however, had little driving power. It consisted mainly of irregular cavalry with only a few guns. When the Kut position was occupied the limitations of the Russian offensive were scarcely understood.

A last consideration, which doubtless influenced General Townshend in his decision to hold Kut, was the necessity of allowing the increasing force downstream as much freedom of action as possible, *i.e.*, space in which to manœuvre in country suitable for manœuvre and well above the swamps at Amarah. The force downstream could then concentrate unhindered and manœuvre freely for offensive action. It would have the initiative.

I have tried to show what were the considerations which induced General Townshend to hold Kut, but there are two sides to every question and many people have disagreed with his decision. He had eluded the Turks by a skilful rearguard action and a rapid retreat, and, though he had not been reinforced to any extent, he then allowed himself to be overtaken and surrounded by greatly superior forces. Again, on his own admission, he underestimated the capability of the garrison to hold out. This was caused partly by incomplete reports of the amount of supplies available in the town (a very difficult matter to estimate), and partly, perhaps, by too modest an opinion of the ability of regular troops to exist on reduced rations. But it was due, also, to his estimate of the condition of his troops. He considered that they were too exhausted to withstand the physical and mental strain of a heavy assault or a long siege. The Indian regiments had lost most of their British officers, and the casualties early in the siege were heavy. Most of the General Officers in Kut considered that a really determined assault by the Turks within the first six weeks would have succeeded if pressed home regardless of losses. The Turks actually assaulted on the 10th and 12th December, 1915, and, on Christmas Eve, they almost captured Kut, but by that time we had some trenches, and the assault was not made in sufficient strength. Anyhow, the underestimation of the garrison's ability to resist the Turks was unfortunate for the relief force, which attempted attacks without adequate preparation in order to save Kut. The repeated failures of the small relief force gave time for the Tigris to rise to flood level and thus to render the relief practically an impossibility. General Townshend, when he decided to remain in Kut, never contemplated a siege of such length as to last till the flood season in March, and he was supported in this estimate of the probable duration of the

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siege by the receipt of a telegram from the Army Commander in which the latter stated that two months might be considered the outside limit before a general move forward would be made by the relief force. General Townshend stated in his book, written after the war, that he did not realize at first that the Turks were being directed by a German staff, and he was consequently surprised at their initiative. The unbroken series of successes of the 6th Indian Division had greatly impressed the population of Iraq and also the Turks themselves, and Townshend considered that the Arabs would exaggerate, in their reports to the Turks, the numbers of reinforcements for the relief force and that the Turks would, in consequence, hesitate to advance much beyond Kut. Events proved that he was mistaken. The Germans clearly realized the situation and sent the Turks to occupy positions as far downstream below Kut as their overland transport would admit. The Turks were soon organized in depth below Kut, and that fact, aided by the floods, gradually brought the relief force to a standstill and finally led to the surrender of the Kut garrison from starvation.

General Sir Charles Townshend was a most capable commander in the field; he had the complete confidence of all ranks during the campaign preceding the siege; he was a keen student of military history and a man of remarkable character; but he was broken by the failure of the attempt to capture Baghdad—one of the most desperate ventures in military history—he was crushed by the change in his luck, by illness, and by the collapse of his hopes. A commander's reputation must depend to some extent on his success. Townshend never failed till he attempted the impossible at Ctesiphon. As the man most conversant with the difficulties of the situation, should he have refused to advance on Baghdad? It is not my business to offer an opinion on this question. But in war there is always the chance that the unexpected may happen, and Townshend, an optimist and born, apparently, under a lucky star, took the chance. He made a magnificent fight, but was overwhelmed. He was forced to retreat, and yet, in retreating he dealt the enemy a shrewd blow at Ummal-Tabul. He longed to find a position in which he could stop his retreat—a movement so repugnant to an ambitious commander who had always been victorious. He reached Kut. He thought he could soon resume the offensive, or at least carry on an active defence and thus retrieve the prestige of his force. He decided to remain. He paid for that decision as a prisoner in Turkey, and a large part of his force paid for it with their lives.

The decision to defend Kut exemplifies the variety and number of the factors which the commander of a force may have to consider, and the extreme difficulty in which he may be placed. Military opinion now appears to incline to the idea that whatever loss of stores, ammunition, prestige, or men, was involved,

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Townshend should not have defended Kut, and that, though he might have halted in Kut for a few days to rest and reorganize his force, he should then have crossed the river and retreated on Ali-al-Gharbi. It was unfortunate that the old Turkish bridge below Kut was dismantled before he arrived from Ctesiphon. It occupied the best and only proper bridge site from an engineering point of view, and it could have been covered and defended till the British force crossed the river. It could then have been destroyed. No bridge which I could make with my remnants of boats after the retreat, could have enabled a whole division to cross the Tigris. In his retreat towards Amarah to meet his reinforcements, General Townshend would have been greatly harassed by Arabs, but he would have had the Tigris between him and the bulk of the Turkish army until the Turks could construct a bridge, and he would then have had a long start. He might have lost 3,000 men from exhaustion in this retreat, but by staying in Kut he caused, directly or indirectly, the loss of nearly 30,000 men. It is easy to be wise after the event. I think, however, that our force would have been capable of resuming the retreat as far as Ali-al-Gharbi, or even Amarah, after three days' rest in Kut, and in the retreat the 6th Cavalry Brigade and the artillery could have held off the Arabs and the Turkish cavalry. Amarah held considerable quantities of supplies and ammunition. It was only about 280 miles by river from Basra, the main base, so that reinforcements could reach it with moderate speed. It seems probable that we could have reached Amarah in ten days from Kut, before the Turks could have bridged the Tigris and overhauled us. Our shipping, with the most essential supplies and our sick and wounded, could have gone with us in the retreat as it did from Ctesiphon. At Amarah the force would have covered Basra and the valuable oil-fields at Ahwaz, and we should have been nearer to our base, and the enemy further from his.

The garrison of Kut, which was really a covering force for the concentration of the British army gradually assembling in Lower Mesopotamia, failed to fulfil its proper rôle for the following reasons :—

(i) Its use as a covering force was neutralized, as its action was to some extent ineffective and it was immobile.

(ii) It did not, except at first, engage a greater hostile force than itself, though it prevented the advance of a greater force beyond Shaik Saad, 20 miles downstream.

(iii) It could not rejoin the main body, or be reinforced without the risk of the defeat of those reinforcements in detail.

(iv) It risked destruction without compensating advantages to the army as a whole.

The Army Commander left to General Townshend, the commander

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of a detachment, the decision as to whether that detachment should remain at Kut as a covering body, or rejoin the main army. The Army Commander was the officer with whom rested the strategical conduct of the campaign. On him depended the arrangements for the concentration of his army for the offensive. On him devolved the duty of securing space for that concentration. He was a keen and capable soldier, his scheme for the capture of Baghdad had failed, and he had great faith in the ability and judgment of General Townshend. Was it, or was it not, his duty to decide whether a covering force at Kut was essential?

In conclusion I may say that my object in writing on such a very controversial subject is that it illustrates clearly the complexity of modern warfare in which a commander has so often to make a rapid decision of vital importance when swayed by many conflicting considerations. All honour to him who, under such circumstances, is capable of a rapid decision, even though fate decrees that it should lead to disaster, but happy is he whose decision leads his troops eventually to victory.

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## *THE POST-WAR ACTIVITIES OF THE ROYAL ENGINEERS.*

INTRODUCTORY.—In the ensuing pages an attempt has been made to summarize the more important events affecting the Corps, outside India, which have occurred since the termination of the war.

Details which are common knowledge to officers serving at home have been included, as it is thought that they may be of considerable interest to officers serving abroad, as well as to retired officers.

ORGANIZATION.—The organization of the Royal Engineers has undergone considerable changes since 1914. The responsibilities of the Corps have been reduced by the separation of the Signal Service from the R.E. and the reduction of the coast defences.

But they have been largely increased by :—

(*a*) The addition of new activities in connection with anti-aircraft work and chemical warfare.

(*b*) The fact that, owing to the general mechanicalization of the Army, engineer work in the field has become very much heavier and more important than in 1914.

(*c*) The addition of transportation units to war establishments.

*Expeditionary Force for Small Wars.*—In 1914 the engineer units, other than transportation units, allotted to the expeditionary force, consisted of a field squadron with a cavalry division ; two field companies per infantry division ; two bridging trains with Army troops ; and two fortress companies, one works company and a printing company with the L. of C.

The post-war organization has been increased so as to include the following :—

Field Squadrons.
Field Companies.
Field Park Companies.
Army Troops Companies.
Field Survey Companies.
Light Bridging Parks.
Electrical and Mechanical Companies.
Tank Bridging Companies.
Workshop and Park.
Field Survey Companies.
Anti-gas Laboratory and Demonstration Units.
First Class Workshops.
Second Class Workshops.
First Class Store Depôts.
Second Class Store Depôts.

In addition, a Searchlight Battalion, R.E., forms part of the Air Defence Brigade which is included in G.H.Q. Troops.

In nearly every case, too, it has been found necessary to increase the war establishments of pre-war units.

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As a result of the increase in both units and establishments the total number of R.E. personnel (other than those for transportation units) required on mobilization for the expeditionary force for small wars has been largely increased above the corresponding total in 1914.

The duties and responsibilities of the field squadron and field companies remain very much as they were.

Army Troops Companies are required for engineer work of a general character such as hutting, water supply, and Electrical and Mechanical Companies for analogous services (including the supply of power generally).

The Field Park Companies consist largely of skilled tradesmen for employment in the divisional area on hutting, water supply, and other kindred services. They also run the Divisional lighting set, formerly operated by the Divisional Signal Company R.E., and provide the organization for the Divisional R.E. stores and workshops, for which personnel had in the past to be withdrawn from field companies. The bridging equipment of the division is also attached to the field park company. It is undesirable to use the personnel, who are difficult to replace, on front line work.

The Searchlight Battalion is organized into a headquarters and four companies, each company being divided into four sections, and each section working six searchlights. Thus there are 24 lights in a company and 96 in the whole battalion.

This unit works in the closest co-operation with the anti-aircraft brigades, R.A.

The requirements of modern artillery, aircraft, etc., have made the compilation and issue of accurate maps more than ever essential. The need of field survey work in an undeveloped and ill-mapped theatre of war is obvious. In 1914 we relied, in the first instance, on the maps of our allies, but speedily developed a large field survey organization of our own.

With a view to keeping the regular peace establishment of the Corps, for financial reasons, at a minimum, in spite of this large increase in mobilization requirements, a considerable number of units is to be provided on a militia basis. The remaining units are to be regulars, but it is not proposed to maintain all of them in peace.

*Field Units.*—There is one field company on the Rhine, the peace establishment being the same as at home—*i.e.*, 4 officers and 111 other ranks—and two field companies in Egypt, with an establishment of 4 officers and 141 other ranks. The increased establishment in Egypt includes 24 additional draught horses, 13 drivers and some 20 sappers, so as to make the units more mobile and able to take the field without immediate reinforcements.

*Fortress Companies.*—The R.E. in fortresses have been very much reduced. The present establishments represent the minimum necessary, and are calculated on a certain scale for each light.

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The establishments abroad have been reduced from a total of 57 officers and 1,365 other ranks to 21 and 522 respectively.

A reduction in officers and other ranks has been effected by amalgamating the two fortress companies at Gibraltar.

Before the war, although the fortress units at home held on their establishment a number of recruits who were still completing their recruits' course in the Training Battalion, their peace establishment was sufficiently large to enable them to lend certain personnel for service with other units, and to give substantial assistance in connection with works services, in peace. It was also possible to draw on them largely on mobilization. With the severe reductions which have been made, it is no longer possible for them to perform these additional functions. It is, therefore, necessary to make additional provision in the Supplementary Reserve to meet the position on mobilization.

*School of Anti-Aircraft Defence.*— The School of Anti-Aircraft Defence, which is situated at Biggin Hill, near Westerham, Kent, gives instruction in the following subjects :—

(*a*) Anti-aircraft defence generally.
(*b*) R.A.F. tactics.
(*c*) Anti-aircraft gunnery and tactical handling of guns.
(*d*) Anti-aircraft searchlight and sound locator work.
(*e*) Camouflage and passive measures from the point of view of defence against aircraft.
(*f*) Aircraft intelligence and communications.

Courses are held for officers and other ranks of the Regular and Territorial Air Defence Troops, and for Senior Officers of all arms.

The Commandant is a Colonel. The first was an officer of the R.E. and his successor, who now holds the appointment, is an officer of the R.A. He is assisted by an Adjutant who, in theory, is a Gunner when the Commandant is a Sapper and *vice versa*. The instructional staff is organized in two wings, an R.A. wing and an R.E. wing and, in addition, there are two small detachments called the R.A. Cadre and the R.E. Cadre. At present there are three R.E. Instructors, while the Cadre consists of one officer and 14 other ranks.

*Anti-Gas School.*—An Anti-gas School was started in 1923 at the Experimental Station, Porton, Salisbury Plain, in order to train regimental officers as instructors for defence against gas. In addition, short courses are held for senior regimental and staff officers. The present output per annum of the school is some 30 senior officers and 100 regimental instructors.

*Boys' Technical School for Training Boys as Tradesmen to Assist in Meeting the Requirements of the Army Generally.*—Great difficulty having been experienced in obtaining sufficient tradesmen recruits from the labour market to meet the needs of the Army, it was decided that endeavours should be made to meet the demand by

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training boys. With this end in view a Boys' Technical School was formed in September, 1923. It had been intended that the location of this school should be at Blandford, but it was subsequently decided that Chepstow would be more suitable.

The School is designed eventually to train approximately 1,000 boys. This number will be reached gradually by sending 110 boys every four months. Before enlistment the boys have to pass a competitive educational examination. They are then enlisted, when about 15 years old, for general service, and for a period of 12 years (8 years' colour service and 4 years' reserve service) from the date at which they attain 18 years of age. They are trained in a trade until they attain the age of 18 years, when they are posted to the various Corps requiring them. At present, trade training is given in the following trades :—Blacksmith, electrician, fitter, carpenter and joiner.

Tradesmen, who have been trained at similar establishments in the past, have attained a very high standard of manual skill and theoretical knowledge, and have proved themselves to be far superior to recruits obtained through the usual channel.

The Commandant of the School is a Lieut.-Colonel, who has under him the necessary administrative and instructional staff. The instructional staff at present consists of a Chief Instructor (Major), an Assistant Instructor (Captain) and 12 N.C.O. Instructors. This instructional staff will be gradually increased *pari passu* with the increase in trainees.

It is anticipated that the School will reach its full strength in May, 1926, when the approximate establishment will be :—

Headquarters : 4 officers, 96 other ranks.
Administrative staff : 8 officers, 20 other ranks.
Instructional Staff : 4 officers, 79 other ranks.
Boys under training : 990.

*Interpretation of Air Photographs.*—Courses have recently been started at the R.A.F. School of Photography, South Farnborough, for training regimental, battalion, etc., instructors in the study and interpretation of air photographs.

The instructor is an Army officer and the position is at present held by an officer of the R.E. The annual output is 60 officers.

*Regimental Headquarters, Aldershot.*—This Headquarters is responsible for the administration of the following R.E. units, which are stationed at Aldershot and are commanded by the senior C.R.E.—

The Mounted Depôt. Five Field Companies. One Field Squadron.

It is considered preferable that the W.O.'s, N.C.O.'s, and men required for Headquarters should be shown separately, rather than be included with the R.E. Mounted Depôt, as in 1914.

*R.E. Mounted Depôt, Aldershot.*—This unit carries out the training duties formerly carried out by the Training Depôt for Field Units. Its functions remain the same as in 1914, *viz.*, the entire training of all

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driver recruits and of farriers and trumpeters, and the training in driving and special field works of all mounted sappers. The establishment is designed to deal with 52 drivers, 20 mounted sappers, 10 farriers and 22 trumpeters at a time. In addition, instruction in equitation, lasting about a month, is given to R.E. officers on their first appointment to field units, or before proceeding to the Indian Establishment. Short refresher courses are also held for officers and N.C.O.'s in field units of the R.E. Territorial Army.

*S.M.E.*—The functions of this establishment are the same as in 1914, with the exception that there are large arrears of instruction to be made up owing to the fact that the course for young officers was very considerably curtailed during the war. In addition, about 31 non-regular officers, who, during or since the war, were granted direct commissions into the Corps, have to complete their full training at Chatham. These officers join the S.M.E. as they become available and undergo instruction at the same time as the young officers and "war-trained" officers. The "war-trained" officers are formed into classes known as "Supplementary Classes," and have been undergoing instruction at Chatham in batches since 1919. During 1920 it was decided that all remaining "war-trained" officers were to complete a portion of their post-war course at Cambridge, after which they were to return to Chatham for instruction in military subjects. The first batch of 50 officers went to Cambridge on 1st October, 1920, and batches of similar strength have continued to be sent to Cambridge up to date. The last batch of this class of officers will proceed to Cambridge on 1st October, 1924.

*R.E. Depôt.*—The R.E. Depôt is organized into two battalions, called the Depôt Battalion and the Training Battalion. It is under consideration to alter the title of the former to "Administrative Battalion," as more adequately describing its functions. Generally speaking, its functions are the same as before the war, although its organization is somewhat different.

The Depôt Battalion :—

(i) Receives men from abroad for discharge and prepares drafts for abroad which cannot be sent direct from units.

(ii) Is responsible for the discipline and administration of the R.E. Band and trade boys who are included in the Depôt Battalion establishment, of the instructional staff of the S.M.E., and of all personnel undergoing courses at the S.M.E., except young officers who are dealt with by the Training Battalion.

(iii) At present holds the documents, arms, equipment, and clothing of the dismounted R.E. Reservists, but the establishment is based on the assumption that the proposal, now under consideration, that all reservists allotted to service

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units shall join them direct and that only the unattached reservists shall join the Depôt at Chatham, will be approved.

The Training Battalion is divided into a Headquarters wing and four companies. It is responsible for :—

(i) The administration of all dismounted R.E. recruits and their training in military duties. It carries out no trade training.

(ii) The discipline and administration of junior officers under instruction at the S.M.E., and their training in military duties, including tactics.

(iii) Certain courses of instruction for officers and N.C.O.'s of the Regular and Territorial Army in military duties.

The Headquarters wing consists of an administrative staff and an instructional staff.

In 1914 the actual number of recruits under training at the Training Battalion averaged about 600. Of these some 304 were on the establishment of the Training Battalion, the remainder being found from within the establishment of other R.E. units. The establishment of recruits, which is based on the peace requirements of the Corps, is now 690. This increase is partly due to the abolition of the pre-war policy of including a proportion of the recruits in the establishment of other units and partly to the lengthening of the training period from 29 to 36 weeks. The battalion is at present accommodated partly in barracks and partly in hutments on the Great Lines, but the question of concentrating it in a single barracks is under consideration. The establishment of the Headquarters wing is based on the assumption that this concentration will be carried out. The duties of this unit as regards young officers will be materially diminished when the number of officers under instruction returns to normal.

*58th Company R.E., Porton.*—This unit, formerly a field company, has since the war been resuscitated for attachment to the Chemical Warfare Experimental Station at Porton, to assist in the work there carried out.

*Officers' Cambridge Course.*—It has been decided that, in future, the time spent at the R.M.A. is to be reduced from 2 years to 18 months, and that all cadets commissioned in the R.E. will complete their training by courses of instruction at Chatham and Cambridge. The total course, including leave and vacations, is 143 weeks, of which 73 weeks are spent at Chatham and 70 weeks at Cambridge. The amount of training done at Chatham prior to proceeding to Cambridge will depend upon the time of year the cadets leave the R.M.A.

The first cadets to do this shortened course at the R.M.A. will be those to enter in September, 1924. This batch will go to Cambridge in October, 1926, together with the batch leaving the R.M.A. in

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August, 1926. As mentioned above, the last batch of "Supplementary Class" officers will go to Cambridge in October, 1924, and will complete their instruction there in the autumn of 1925. Thus there will be a period from October, 1925, to October, 1926, when there would normally be no R.E. officers at Cambridge. For various reasons it is considered very undesirable that there should be any hiatus, so 17 selected candidates from the batches passing out of the R.M.A. in January and August, 1925, will be sent to Cambridge to fill it.

*Engineer Services.*—The withdrawal of the Imperial Garrisons from Iraq, Palestine, South Africa and South Ireland, the paramount necessity for economy, and various changes in organization which are referred to more fully below, have led to considerable reductions since the war in the establishments of officers and subordinates employed on engineer services. In 1921 the subordinate establishment cost £825,000. This year it is estimated to cost £410,000. In 1921 the number of officers employed on engineer services was 429. This year it is 227.

In carrying out the reorganization of works establishments rendered necessary by these large reductions, endeavours have been made to improve matters by :—

(*a*) Reducing the number of C.R.E.'s and D.O.'s appointments and enlarging the areas of their charges.
(*b*) Standardizing these charges as far as possible upon a basis of comparative average expenditure.
(*c*) Further decentralizing technical and financial responsibility.

The chief object aimed at (in addition to economy) has been to increase an officer's responsibilities and powers with a view to making employment on engineer services in peace afford more adequate training for war.

There are, however, and must be under present conditions, certain D.O.'s appointments at home stations which, either owing to their geographical situation or to the fact that the work is chiefly confined to minor maintenance, do not afford useful training and experience to an R.E. officer at all. There are others which are only suitable to be held by junior officers. All D.O.'s appointments at home have, therefore, been graded in accordance with their importance, and postings are made to correspond.

The procedure to be adopted in filling appointments which are not suitable for R.E. Regular officers to hold is still under consideration.

## ADMINISTRATIVE CHANGES.

*Replacement of the Royal Engineer Committee by the Royal Engineer Board.*—The R.E. Board was formed in August, 1920, to take over

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the work which had been previously carried out by the R.E. Committee, the objects being :—

(*a*) The prosecution and guidance of scientific research.

(*b*) Experiment and design in connection with engineering equipment and material required for the R.E. and the Royal Corps of Signals.

(*c*) That the Board should act as an intermediary between the War Office and the productive engineering resources of the community in carrying out the general lines of policy laid down by the General Staff in regard to such material and equipment.

The R.E. Board is also responsible for studying the progress made by the above-mentioned branches of the Service in foreign armies and developments in engineering in foreign countries.

*The duties and responsibilities* of the Board in pursuit of the foregoing objects are as follows :—

(*a*) *Research and Investigation.*—To decide upon matters entailing research and maintain touch with Scientific Associations and Technical Institutions which undertake it, and other Government Departments.

(*b*) *Experiments.*—To determine the scope and extent of experimental work, the allocation of this work to the various Experimental Establishments or elsewhere and the control of the technical work of these establishments.

To furnish technical reports upon inventions or proposals referred to them.

(*c*) *Design.*—To design or to arrange for the design and preparation of specifications (with due regard to the utilization of commercial products) of technical machinery, material and stores for Military Engineering, and Signals, and to make recommendations as to their adoption in the Service.

(*d*) *Records and Intelligence.*—To collect and collate such information :—

(i) Regarding scientific and engineering developments in the British Empire as may be published or otherwise made accessible, with a view to its adaption to Military Engineering, and to facilitate making full use of the technical resources of the Empire in Military Operations.

(ii) As published in foreign scientific and technical journals regarding engineering developments in foreign countries.

(iii) As shows progress made in the organization and technical equipment of the Engineering and Signals branches of foreign Armies.

(iv) To disseminate the above information to all concerned.

*Constitution and Organization.*—The Board consists of a permanent central body composed of a President, three members and a secretariat, who have no other duties, together with certain *ex officio*

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members. With them are associated representatives of other Experimental and Educational Establishments, of the branches of the War Office concerned, selected Regimental Officers, and representatives of other Government Departments and Engineering Institutions. As a matter of convenience, it is found desirable to subdivide into committees, and to hold separate meetings for those concerned in the various subjects, for example :—

| | |
|---|---|
| (i) Bridging ... ... ... ... ... | Committee A. |
| (ii) Mining, Demolitions and Explosives ... | |
| (iii) Camouflage ... ... ... ... | |
| (iv) Survey and Photography ... ... | |
| (v) General Field ... ... ... ... | |
| (vi) Electric and Mechanical Equipment, Water Supply ... ... ... | Committee B |
| (vii) Searchlights ... ... ... ... | |
| (viii) Sound Locators and Acoustics ... | |
| (ix) Signals, General ... ... ... | Committee C. |
| (x) Signals, Wireless ... ... ... | |

*Experimental Establishments.*—The undermentioned Experimental Establishments are under the direct control of the Board as regards all experimental work carried out by them :—

(i) Signals Experimental Establishment (Woolwich).
(ii) Searchlight Experimental Establishment (Biggin Hill).
(iii) Experimental Bridging Company, R.E. (Christchurch), Experimental Section, R.E. (Christchurch).

*Office of the A.A.G., R.E.*—The responsibilities of this branch of the War Office remain unchanged, with the exception that the A.A.G. now holds the dual rôle of A.A.G. for R.E. and A.A.G. for Signals, and he has a D.A.A.G. to assist him in the administration of the latter Corps. The A.A.G. is also responsible for the administration of the Boys' Technical School, referred to elsewhere in this article.

The number of R.E. regular officers is still considerably less than that required by the peace establishment, thus rendering it necessary to employ a number of temporary officers.

*D.F.W.'s Branch.*—No great administrative changes have been made in the D.F.W.'s Directorate, although the great advance in electrical and mechanical functions, and the demise of the Director of Barrack Construction's Department, has necessitated a considerable increase in the staffs of the branches dealing with these subjects.

The powers of local officers as regards :—

(*a*) Approval of designs, (*c*) Purchase of Stores,
(*b*) Sanctioning Services, (*d*) Making Contracts,

have been considerably increased.

The selection of all "Capital" Services for execution costing less than £1,000 is now left to the Commands.

The responsibilities of D.O.'s as regards measurements have been reduced by the appointment of an Inspector of Works to each

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C.R.E. for employment on surveyors' duties only—a reversion to the practice which obtained prior to 1907.

In most home Commands the employment of direct labour has been superseded by lump sum or term contracts.

The introduction of cost accounting has necessitated a complete change in the system of engineer accounting formerly in force. The new system is necessarily more complicated than the old, and is somewhat more expensive.

Advantage was taken of the change to revise the R.E. system of store accounting by the introduction of a stock or suspense account to which the purchases are debited in the first instance, credit being given by their user in due course.

Every Army Form used in connection with Engineer Services has been reviewed, and as many as possible have been either simplified or abolished. But the introduction of cost accounting has necessitated the introduction of a good many new forms.

Sections VI, XII and XIII of the *Regulations for Engineer Services* have been re-written and promulgated. The revision of the whole book, and of the *Instructions for Fixed Electrical Communications* is now in hand. The former is in proof stage and should be issued shortly.

The issue of the new *Schedule of Prices for Works and Repairs* has facilitated the reversion to contract procedure referred to above.

In connection with the new system of Engineer accounts a *Priced Vocabulary of R.E. Stores* has been prepared and issued so as to ensure uniformity of pricing at all stations. It is now in course of revision.

A new *Barrack Synopsis* and new *Drainage Manual* have also been issued.

### Pay and Conditions of Service of Personnel.

By the issue of Army Orders 324 and 325 of 1919, the total emoluments of effective and non-effective officers and other ranks of the whole of the Army were considerably increased on account of the increased cost of living. In the case of officers it was stated that the revised rates were subject to revision after 5 years, either upwards or downwards, to an extent not exceeding 20 per cent. according as the cost of living rises or falls. No such stipulation was made in the case of other ranks.

This revision—a reduction of 5½%—has just been promulgated. A further revision will be made with effect from 1st July, 1927.

Although the total emoluments of officers were considerably increased by Army Order 324 of 1919, the rates of Engineer pay for R.E. officers were reduced. The issue of Engineer pay to officers joining subsequently was also made dependent upon officers qualifying as Associate Members of the Institution of Civil, Mechanical, or Electrical Engineers, or upon their possessing such other equivalent qualifications as might be accepted by the Army Council. A proposal

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is under consideration to substitute an examination to be held by Cambridge University for the outside qualifications referred to above.

A considerable number of civil engineers, and subordinates, were recruited on short-term contracts for service in Iraq in connection with works. On termination of the War Office responsibilities there, they were either discharged or transferred to the Air Ministry.

Sanction has been obtained for amelioration of the pay and conditions of service of the permanent Inspectors of Works, thus removing a long-standing grievance. The conditions to govern the recruitment of their successors are still under consideration.

Subject to careful scrutiny of annual staff estimates and subsequent local inspection, Commands are now given a free hand as regards the engagement and discharge of civilian subordinates employed on works services within the limits of the bulk allotments made to them for payment of staff.

The pay of civilian employees has fallen considerably in accordance with civil rates. The pay and conditions of service of the civilian mechanists, Foremen of Works, and R.E. storekeepers have been improved and now conform to their responsibilities. A scheme for making civilian Foremen of Works, Surveyor's Clerks, draughtsmen and clerks employed on Engineer Services pensionable is being considered.

By the issue of Army Order 325 of 1919, the old system of granting rates of Engineer pay was abolished. Trades were divided up into groups, and each group was sub-divided into classes. Tradesmen's pay is now drawn by all arms of the Service which have tradesmen on their establishment. This necessitated the revision of all existing trade tests and the institution of new ones. To secure uniformity in dealing with this question, a Trades Committee was formed under the Presidency of the A.A.G., R.E. The duties of this committee, serving on which are representatives from all the technical arms of the Service, include the drawing up of trade tests for every trade in the Army, and dealing with questions arising therefrom.

In order to insure uniformity in carrying out trade tests, Command Testing Boards have been formed, which have authority, with the approval of the G.O.C.-in-C. or G.O.C., to convene Area Testing Boards to carry out the actual tests. Full details of the various tests and of the necessary procedure are contained in the *Regulations Governing the Issue of Tradesmen's Rates of Pay*,

## CORPS ACTIVITIES.

*Boundary Commissions, etc.*—The termination of the War has necessitated the formation of numerous Boundary Commissions, on a number of which R.E. officers have been employed, *e.g.*, German-Polish, Saar Valley, Germany-Belgium, Austria-Italy, Hungary, Jugo-Slavia, Hungary-Czecho-Slovakia, Albanian-Serb-Croate, etc.

R.E. officers have also been extensively employed on the Military Inter-Allied Mission of Control at Berlin, and on the Railway Sub-

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Commission of the Inter-Allied Railway Commission at Wiesbaden. An R.E. officer has also been employed on the Supreme Economic Council, and as British Arbitrator on the Arbitral Tribunal under the Colonial Office to consider the claims of compensation against His Majesty's Government and the Government of Palestine by the Jaffa-Jerusalem Railway Company. This officer was also employed under the Foreign Office to form one of the British Delegation to Paris to discuss the future status of Tangier, particularly in regard to the question of Tangier Harbour, which for years had been a subject of dispute between the British, French and Spanish Governments, and for which an expert of technical knowledge and diplomatic experience was required.

*Turkey.*—The occupation of Constantinople by a large Allied force at the end of the War threw a great deal of work on the R.E. The British troops were spread over a large area with many small and shifting detachments. In addition to holding the city of Constantinople itself, the British force had detachments throughout the area extending north to the Black Sea, on the west to the Bosphorus, as well as across the Bosphorus from Haidar Pasha (opposite Constantinople) northwards and eastwards from Ismid. Chanak and its vicinity, in the narrows of the Dardanelles, was occupied as well as the town of Gallipoli in the Peninsula of that name. Later on detachments were sent to Thrace and to the Ismid Peninsula; still later the recent Near Eastern crisis developed. This involved much work for the Corps at Kilia, described in a recent article in the *R.E. Journal.* For a short time also the Chatalja front was occupied.

At all these places the R.E. work was of the nature usual to such occupation, *e.g.*, the improvement of water supply, making hutted camps, improving the poor Turkish barracks and billets, installing electric light, etc., etc. At first large numbers of troops were under canvas, but hutting became necessary as winter approached. When the occupation started, work was carried out under war conditions, but as time went on the usual peace methods of accounting were gradually resorted to. Changes in policy led to rapid variations in the strength of the force and in its distribution, with the result that the rôle of the Engineers was made extremely difficult. In September, 1919, the strength of the British force was some 45,000; by February, 1920, it had dropped to 23,000. It then increased again temporarily, only to drop again in the autumn of 1920 to 15,000 and then to 11,000. During 1919–20 the cash expenditure on Engineer Services amounted to £150,000 and in 1920–21 to £230,000.

*Iraq.*—The conclusion of the Armistice found the troops in Iraq occupying tents, huts and such accommodation as could be found locally. For the next 16 months this accommodation was supplemented at the discretion of the G.O.C., during which time the administration of Engineer Services was carried out from India, the War Office merely providing the money. This dual system of control led

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to much delay, so from the 1st April, 1920, the War Office took over the administration.

In the absence of a decision as to the boundaries of the territory to be held, it was impossible to lay down any definite general policy, and consequently any definite works policy. Most of the troops, still quartered under active service conditions in tents and temporary shelters, were therefore not merely without comforts, recreational facilities and other conveniences normally provided for soldiers in time of peace, but were exposed to a climate which was dangerous to the abnormally young personnel then garrisoning the country. To a certain extent the situation had been relieved by billeting, but this, in addition to being an undesirable expedient, was very expen sive. In October, 1919, the annual cost of billets in Baghdad alone was £28,000, and threatened to reach £98,000 in the event of payment at the rates for which the Civil Commissioners were pressing. Further serious loss was accruing from the deterioration of tentage and the pilfering of stores kept under canvas. The value of tentage alone was estimated at £1,250,000 and the annual cost of maintenance £500,000.

That permanent or semi-permanent barracks would be required was evident. The matter became urgent. In April, 1920, it was decided to provide accommodation for 1 Infantry Brigade, 1 Cavalry Regiment, Headquarters and other troops, making a total of 6,000 men. These buildings were to be of mud brick on permanent foundations, a type of construction largely used in India, as affording excellent protection against the heat. All buildings, other than those required at the base at Basra, were to be concentrated in the first instance at Baghdad. The proposed cantonments were to be at Baurah and Hinaidi—sites to the south of Baghdad occupied by existing camps. Certain roads, drains, water and lighting services, already provided at a cost of £142, 000, were available for the service of the new buildings. The cost in cash was estimated at £1,500,000. Subsequently, further provision was required in connection with water supply, hospitals, ordnance depôts, etc.

As in the case of Turkey, political uncertainty rendered the work very difficult and expansion and progress slow. In April, 1922, whilst it was still incomplete, the War Office handed over charge to the Air Ministry. At that time the following additional items had just been commenced :—

| | |
|---|---|
| Electric Power Plant, Hinaidi ... ... ... | £61,000. |
| Engineer Shops and Stores, Hinaidi ... ... | £3,000. |
| Concentrate S. and T. Depôt, Hinaidi ... ... | £4,000. |

*Palestine.*—For two and a half years after the Armistice the troops in Palestine were accommodated in standing camps and commandeered buildings. A certain amount of winter hutting had been erected, but most of the men were still under canvas and lived under conditions of much discomfort. About June, 1921, it became clear that

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it would be necessary to maintain a force in Palestine for a considerable period. The cost of upkeep of the temporary camps was considerable and some 4 millions in all had already been spent on them. It was, therefore, decided that cantonments should be constructed for 75 per cent. of the force at Ludd and for the remainder at Jerusalem, Jenin and Nazareth. Only preliminary work, such as water supply, roads, etc., was to be started in the first instance at the three last-named stations. In this way there would be a minimum loss in the event of a subsequent reduction in the strength of the force. As a result of this decision work was started at once at Ludd and elsewhere and £600,000 was provided in estimates for these cantonments.

However, the political situation was still very uncertain, and a few months later Mr. Churchill suggested that the whole of the British garrison should be withdrawn, leaving only Indian troops and one or two squadrons of the Royal Air Force, the whole to be administered by the Colonial Office. It was also suggested that the Colonial Office would probably delegate the administration of troops in Palestine to the Air Ministry in the same way as arranged for Iraq.

Owing to further changes in policy much work had to be suspended, although a good deal was done. About 100 barrack huts which had been sent out from England had been erected by the end of 1921. The huts were of timber framing with " trussit " (a form of expanded metal) and cement walls and plaster lining ; the roofs being of corrugated iron and timber lining. The huts proved very satisfactory.

In 1922 further constructional work was carried out, including the erection of a number of store huts sent out from England. In addition, much progress was made in well boring, and water supply at Ludd was considerably improved. Many miles of metalled roads were constructed in the new cantonments. About June, 1922, the Air Ministry took over control in Palestine on the lines already suggested and relieved the R.E. of all further responsibility.

*Engineer Services Generally.*—Administrative and executive officers have carried on under conditions of extreme difficulty during the period under review. Policy has been subject to rapid fluctuation, due firstly to the " establishments " of the post-war Army not being fixed, and secondly to the absence of a decision as to the final peace stations of the Army. It was consequently necessary so to arrange work each year that programmes could be rapidly stopped down instead of being completed. Furthermore, it has never been possible to ensure that the funds for continuing any particular service would be forthcoming in succeeding years. The maintenance, and subsequent transfer of works services in Iraq and Palestine, affairs in Ireland, industrial unrest, the non-conclusion of peace with Turkey, and the occupation of the Ruhr, with all its consequent repercussion on the Army of the Rhine, have all contributed to the difficulty of smooth and economical administration of works services.

The formation of new units, (*i.e.*, Tank Battalions, Air Defence

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Brigades), the establishment of new schools (*e.g.*, Tank School at Bovington, the School of Military Administration at Chisledon, now defunct), the inception of the new scheme for securing tradesmen for the Army, (*e.g.*, the Boys' Training School at Chepstow, see above), the broadening of the scope of the married roll, the recognition of the married officer, and the necessity of research work in connection with chemical warfare, resulting in the establishment of the Porton Experimental Station, have all thrown an immense amount of work on the Corps, not only in administering the schemes actually carried out, but in preparing and examining the numerous alternatives which never mature at all. At the end of the War, enormous numbers of huts became surplus to requirements, and, as the most pressing need at the time was for the provision of married quarters, many of them were converted to meet the need, more especially in view of the very high prices then ruling for permanent building materials.

With the gradual exhaustion of the supply of huts, the rapid deterioration of those still remaining unused, and the necessity for clearing camps, a return to brick construction is now taking place: the fall in prices since 1919–20 has rendered the difference between cost in permanent material and cost in hutting much less marked.

Since 1920 some five million pounds have been expended on "capital" services, six million pounds on "maintenance" services, and four million pounds on services necessitated by the reinstatement of private property used for war purposes.

*Electrical and Mechanical Services.*—Considerable progress has been made in installing electric light in barracks, resulting in large economies in actual cost of lighting and at the same time adding to the comfort of the troops. Progress has been made in the modernization of some of the more important W.D. power stations, with the result of reducing the annual running costs.

Further economies in annual costs have been obtained by the introduction of electric power drive into W.D. installations instead of steam or oil prime movers.

*Design and Research Work.*—A standard floating (medium) bridge has been designed to replace the old pontoon equipment and 7 bridges (126 ft.) of this type are being ordered in 1924–25.

Far-reaching results may be expected from the results of research work carried out in sound location.

Wireless sets to stand the conditions of war have been evolved and produced in consequence of the expansion of the use of wireless in the field.

Considerable progress has been made in the search for efficient Anti-Aircraft projectors (and their accessory equipment).

A new system has been adopted for the rapid erection of field telegraph lines to carry 16 wires.

Progress in wireless telephony continues and a start has been made in research of wireless mechanical transmitters.

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# *THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR*, 1914–19.

## EXPERIMENTAL SECTION.

THE Experimental Section grew from small beginnings. It originated in a detachment to manufacture hand-grenades organized in October, 1914, at St. Omer, by Lieut.-General Sir G. H. Fowke (then performing the duties of Engineer-in-Chief, but officially styled Engineer Adviser attached G.H.Q.). It was first under the command of Lieut. (now Captain) E. S. R. Adams, M.C., Special Reserve, R.E., who, on being ordered to the Ministry of Munitions, London, was succeeded by Lieut. (now Major) C. G. H. Bellamy, O.B.E., R. of O., R.E. The Corps was exceedingly fortunate in being able to command the services of two such officers. Backed up by Serjeant (later Q.M.S.) Griffin, R.E., and a party of N.C.O.'s and Sappers, they never failed to invent and manufacture at the shortest notice any device required by the General Staff. They developed and investigated the improvement of the service stores mentioned in the account, and conducted trials of inventions submitted. Although they had to handle many dangerous weapons, bombs, grenades, etc., they did so with so much care that the Section did not have a single casualty: for Lieut. Breeze, who was unfortunately killed by the explosion of an experimental rocket bomb, though working with the Section, did not belong to it, and was under the direction at the time of the inventor, the American, Colonel Lewis. The Section may well be proud of its record.

### CHAPTER I.—GENERAL HISTORY.

The History of the Experimental Section dates back to the early period of the War, after the British Army had left the Marne, and when the first Battle of Ypres had been fought and the German rush to the coast definitely checked.

General Headquarters was then located at St. Omer, and amongst many units forming G.H.Q. Reserve was the 2nd Bridging Train, R.E.

The opposing armies having dug themselves in, in preparation for the coming winter, a demand naturally arose for weapons suitable for trench warfare, and the Indian Corps were amongst the first troops to use a trench mortar in its simplest form. What was probably the first 90-mm. trench mortar was made at a small paper

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factory outside St. Omer. The mortar consisted of a steel tube, and was mounted on steel legs with a flat steel base plate.

It was at this period, during the month of October, 1914, that the O.C. of the 2nd Bridging Train, R.E., was called upon by the Brig.-General R.E., G.H.Q. (Brig.-General G. H. Fowke), to furnish an officer to make suitable ammunition for the 90-mm. mortar from whatever local materials that were available.

The officer, Lieut. E. S. R. Adams, Special Reserve, R.E., who was detailed for the duty, had already had practice on the Aisne in manufacturing hand grenades from jam tins to supplement supplies to Field Companies, and had also had civil workshop experience before the War.

*Formation of the Section.*—In the barn of a farmyard of the château at Tilques, near St. Omer, the unit which eventually became the Experimental Section, R.E., was founded, and for two months, until the end of December, an officer with 8 Sappers of the Bridging Train manufactured ammunition for the 90-mm. mortar, and during this period produced several hundred projectiles. At the same time another improved pattern of hairbrush hand grenade was turned out in considerable quantities and supplied to the troops in the line.

*Rocket Gun.*—In January, 1915, the B.-G., R.E., directed that experiments should be taken in hand to develop an invention brought out to France at that period by Colonel Lewis, of the American Army, the inventor of the Lewis gun. The invention consisted of firing from a mortar a shell on the principle of the rocket, and considerable experiments were carried out with it. The mortar and shells were manufactured locally, except for certain parts which had to be obtained from London or Paris.

These trials continued for some considerable time and were successful, but, owing to the great visibility of the trail of the rocket and consequent danger of the battery position being easily located, together with the erratic flight of the projectile, the rocket gun was dropped and superseded by the 2-in. trench mortar produced at Woolwich, which fired a projectile commonly known as the "football" bomb.

During this period, the workshop was removed to the château at Tilques, and in March a corporal (Corporal S. Griffen, R.E.) and eight men were detailed from the 29th Advanced Park Co. R.E., G.H.Q., to supplement the small staff of Sappers available from the Bridging Train.

*Rifle Grenades.*—In the summer of 1915 the demand for grenades was insistent, and in August the Experimental Section was transferred to St. Omer and fitted out with a barge on the canal. The barge was equipped with a 5 h.p. Aster engine and one lathe, which was obtained from Paris, and another lathe from the 29th Advanced Park Co., R.E.

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The Section became then definitely (though unofficially) part of the R.E. Establishment at G.H.Q., and the officer in charge became known as the Experimental Officer to the Chief Engineer.

Experiments with rifle grenades continued for a considerable period. The No. 3 Hales rifle grenade had been in use for some time, but in small quantities. The demand for a good rifle grenade was considerable, and, to meet the demand, the No. 5 Mills grenade, in use as a hand grenade, was fitted with a rod; the cup attachment introduced later into the Service was the production of the Experimental Section.

About this period, the Newton, Sangster and Townshend rifle grenades appeared, and considerable experiments were carried out to devise a good percussion rifle grenade both in England and in France during the winter of 1915-1916. Two patterns were made, but difficulties in manufacture in England prevented these being taken up.

Of those produced in local army workshops in France the Newton was the only grenade which eventually went home for manufacture, and for some time the No. 5 Mills hand, No. 23 Mills rifle, No. 20 Hales (modified No. 3) and No. 22 Newton grenades, were all manufactured and sent out from England, and supplemented by local supplies from workshops in France.

*General Experimental Work up to* 1916.—During the summer and autumn of 1916, considerable experimental work was done in connection with devising simple types for manufacture in bulk, either in England or in the army workshops, of varied trench warfare stores and devices, such as trench barriers, parapet shields, rifle clinometer for grenades, screw pickets, torpedoes, portable charges, etc. Experimental work was also carried out with various grenade throwers, spring guns and catapults.

In October, 1916, the 3-star parachute signal was initiated, and eventually the No. 27 smoke rifle grenade with yellow phosphorus was developed, and this superseded the red phosphorus "P" bomb with its various types of fittings for firing from the rifle.

In the early part of 1916 the first percussion flare to fire from the 1½-in. Very pistol was suggested, and a flare was designed and produced in the Experimental workshop which was made and tested with very good results, and was sent home for manufacture in quantity.

*Inventions Committee.*—During the whole of this period, the Experimental Officer to the Chief Engineer, apart from his duties in the experimental workshop, had been a member of the Experiments Committee formed in June, 1915, and consisting of officers appointed by the General Staff, Artillery Adviser, and Chief Engineer. Inventions submitted to G.H.Q. in connection with trench warfare stores and devices were considered by the Committee, and action taken accordingly; and experiments were carried out whenever the suggestions put up warranted further investigation. The Experiments

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Committee, though not definitely abolished, eventually dissolved, and the Experimental Officer R.E. was called in by the General Staff to advise directly on various inventions submitted, the experimental work being closely followed by the General Staff and directed as occasion demanded.

Efforts were made to have the Section brought officially on to the Chief Engineer's Establishment, but for various reasons this was not approved.

*Move of General Headquarters.*—In March, 1916, General Headquarters moved to Montreuil-sur-Mer, and the Section took up its abode in the back shed of a private house by the South Gate near the main Montreuil–Abbeville road.

At this time the Section consisted of 1 officer, 1 serjeant and 8 sappers of various trades, and had 2 lathes, 1 drilling machine, 1 blacksmith's forge and 1 acetylene welding plant, together with various bench tools—a press, shears, etc.

Experimental work during the autumn of 1916 had been concentrated on devising improvements in rifle grenade cartridges, and experimenting to ascertain the causes of accidents when firing rodded rifle grenades. The 35-grain cordite rifle grenade cartridge had never been satisfactory, and a considerable number of burst barrels and prematures with the grenades were occurring. It was owing to these experiments that the cause of many accidents was traced to the use of wax wads in the mouth of the cartridge, which had been inadvertently introduced during manufacture in England.

*Change in Command.*—About the end of 1916, it was decided that it would be an advantage to have an officer in the Ministry of Munitions who had had experience of the requirements of the British Armies in France, and who had sufficient technical knowledge to be able to assist in controlling the design of various stores demanded from England from time to time, and who, in this capacity, would be able to represent the views of the General Staff on the subject of trench warfare production. The Experimental Officer (Lieut. Adams) was therefore transferred to the Design Branch of the Ministry of Munitions, and in March, 1917, handed over his duties at G.H.Q. to an officer from the 29th Advanced Park Co. R.E., Lieut. C. G. H. Bellamy, Special Reserve, R.E.

*Further Developments in Grenades.*—About Christmas, 1916, a change had come in the history of grenades, when the introduction by the French of a bulleted round grenade, fired from a cup attachment on the rifle, drew attention to what appeared to be a great stride in the development of rifle grenades. The attachment of a cup discharger on the rifle did away with the necessity of fitting rods to the grenades—a continual source of damage to the rifle—and an endeavour was made to devise some means of attaching a discharger cup on to the Short M.L.E. rifle in use by the British Army.

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Various fittings were made and experimented with and in March, 1917, an officer of the Munitions Inventions Department brought out to France a fitting which was taken up as being the best design, and a demand arose immediately for supplies of dischargers fitted to the short rifle, and which could fire the Mills grenade.

Experimental work then was turned on to evolving a gas-port for varying the range, and the Experimental Section produced a pattern, which in April, 1917, was taken home to the Ministry of Munitions, and was used as a guide in designing the type which was embodied in the discharger eventually produced.

In June, 1917, a revised establishment was approved for the Engineer-in-Chief's Office, and the appointment of Experimental Officer, graded as a Staff Captain, was included in this establishment.

*Smoke Screens.*—Considerable experimental work was done during the summer of 1917. A demand arose for smoke barrages for operations in screening infantry concentrations and attacks and also artillery positions, and a smoke case was evolved which was made of materials supplied by Ordnance, mixed and poured into 18-pounder shell cases. A small party of the Section was sent to the Fourth Army on the coast to manufacture these cases in quantity, and during the six weeks they turned out several thousands with the assistance of local labour.

*Armour Plating Protection.*—Considerable trials were carried out during the summer of 1917 to find a material for facing loop-hole plates as a protection against armour-piercing bullets. In April, 1917, the armoured cars of the Cavalry Corps were found to be penetrated by German armour-piercing ammunition. After experiments were carried out, the cars were fitted with sheets of uralite as a protection, but not with very satisfactory results. Trials with Japanese parapet shields showed that uralite was one of the best protective coverings, but that no material light enough to be of practical use offered any appreciable protection, and these experiments were dropped.

*Combined Hand and Rifle Percussion Grenades.*—In the summer of 1917 endeavour was made to evolve a suitable design of percussion grenade mechanism for a grenade for combined hand and rifle use. The discharger, in doing away with rodded rifle grenades for a range up to 200 yards, necessitated using the Mills time grenades without a rod, but fitted with a flat steel gas check. With its extra time of burning of the fuze for a maximum range of 200 yards, the Mills rifle grenade was introduced into the Service as the No. 36. Several types of hand percussion grenades had been submitted to G.H.Q., including the Humphries, Nissen, and Daniels and Gardner grenades, but none of these were quite satisfactory. Experiments were carried out to improve the Nissen percussion mechanism and a bulleted round grenade on the same lines. The Experimental Section tested

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all the types submitted and reported on their various defects, and suggested methods for improving them. It became evident at this period that, if a satisfactory percussion mechanism could be evolved, which was simple to manufacture, another big step in the development of grenades would have been reached.

The Egg grenade had been previously developed with a "hit" mechanism on the same lines as the phosphorus grenade and 3-star signal, and was known as the No. 34 Egg grenade. Experiments were carried out to fire this from the Mills discharger or a discharger with smaller diameter, but owing to the development of percussion mechanisms, and obvious advantages of such, the method of firing the Egg grenade from the rifle was not introduced. Eventually about December, 1917, a promising percussion mechanism was evolved in the Experimental Section shops, and the Ministry of Munitions were asked to turn out a large quantity for trial purposes.

During the winter of 1917 the workshop was increased considerably in size.

In order to cope with the work, the Section was given a second officer, a trained mechanical engineer, Lieut. J. McAllister, R.E., who had served 2½ years in the infantry.

With this extra assistance a larger variety of experimental work was enabled to be taken up.

The demand for repetition work for making percussion mechanisms and other devices necessitated obtaining more lathes and other machinery. The shop was therefore equipped with a capstan lathe, a shaper and power press, and another shop was erected behind the buildings, in order to accommodate the tinsmith, carpenter and extra blacksmith, and also stores to contain explosives and grenades.

Various other devices were experimented with at this period, including the development of the mud punt, designed by Lieut.-Colonel Nissen, and the design of a suitable model aeroplane track for training machine gunners at the Lewis gun schools.

*Anti-Tank Defence.*—In the early spring of 1918, a demand arose for contact mines for anti-tank defence, and these were satisfactorily developed, the mechanism depending on the shearing of a gramophone needle. Considerable quantities were used prior to the German attack in March.

An anti-tank grenade was also developed, and, after a long series of exhaustive experiments, the No. 44 grenade was evolved, which proved to be a very deadly weapon.

Various experiments with machine-guns and mortars were undertaken during the summer of 1918, and at this period the duties and scope of the Section had considerably increased.

The duties at that time consisted of the following :—

Experimental work.

Investigation of new types.

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Improvement of existing types.
Reports as to the suitability of new types.
Investigation of accidents and general advice as regards:

(1) Hand grenades.
(2) Rifle grenades.
(3) Rifle grenade dischargers.
(4) Grenade guns.
(5) Firework signals for all branches of the Service, including the R.A.F.
(6) Light machine-guns in connection with mountings and various mechanisms connected with the same.
(7) S.A.A.—including tests for penetration of all types.
(8) Loophole plates.
(9) Parapet shields.
(10) Body armour.
(11) Periscopes.
(12) Hyposcopes.
(13) Smoke generators.
(14) Illuminating devices.
(15) Message-carrying projectiles.
(16) Mines.
(17) Light mortars and mountings.

This work included comparative trials between British and German types, and trials of types used by other Armies in the field.

The Experimental Section was responsible for compiling technical portions of handbooks dealing with the experimental workshop, and also to the Engineer-in-Chief for giving such advice under the above headings as was necessary to enable the General Staff to decide the various questions of policy which constantly arose.

*Dangerous Nature of the Work necessitated Change of Site.*—During the whole history of the Section, for a period of over four years, although continuously dealing with explosives and materials, no serious accident occurred, with the one exception of the fatal accident to Lieut. Breeze, an assistant of Colonel Lewis, killed by a premature during the closing experiments with the Rocket Gun.

This general good fortune was greatly due to the care and skill of the senior N.C.O., Serjeant (afterwards Q.M.S.) Griffin, a regular R.E., who invariably did the really dangerous duties himself.

The congestion due to increasing work, as well as the possibility of danger to the local inhabitants, made a change of site essential, and in 1918 the use of a field outside the town was obtained, and the necessary buildings erected.

The office of the Officer in Charge of the Section was moved at the same time from the Headquarters offices to this new site, and the Section became practically an independent unit.

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In September, 1918, with the approval of the General Staff, an establishment for a separate unit was drawn up, and was eventually sanctioned in October.

The unit then consisted of the following :—

1 Major.
1 Lieut.
1 Q.M.S.
2 Corporals. } Artisans.
10 Sappers. }
1 Clerk.
3 Draughtsmen.

with one box car.

The last period in the history of the Experimental Section during the winter of 1918–1919 was spent in the development of the Lewis gun, percussion grenades, Stokes mortar, anti-tank Stokes mortar mounting and various miscellaneous fireworks and stores.

Considerable time was spent during the summer of 1918 by both the officers of the Section on the evolution of an aeroplane height finder and a system of automatic sights for aeroplanes. Two height finders were evolved, one of which was introduced into the Service for instructional purposes at Schools.

*Aeroplane Height Finders and A.A. Automatic Sights.*—The system of automatic sights was demonstrated to a committee at the Lewis Gun School, and created a very favourable impression.

It was proposed by the officers concerned to make it the subject of a special paper, and to offer it to the Government, after the principles had been protected, as it was chiefly applicable to anti-aircraft guns.

*Lewis Guns.*—Experimental work on the Lewis gun consisted of evolving a satisfactory method of varying the rate of fire, and a suitable mechanism was demonstrated at the Lewis Gun School with satisfactory results.

At the same time, a simple trigger mechanism was designed, by means of which single shots could be fired at will, and which could be clamped to the gun without alteration.

Samples were being made, as it was proposed to introduce this, when the Armistice was signed.

All this experimental work was carried on before the light Lewis gun had been introduced, for by means of a single-shot firing mechanism the radiator and casing of the standard Lewis gun could be dispensed with, thereby reducing the weight of the gun by about 9 lbs.

When the new light gun with its single-shot firing mechanism arrived in France no further experiments were made with the slowing-down gear, and attention was turned to designing a mounting for

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the Stokes mortar, by means of which the mortar could be fired at low angles for anti-tank use.

*Stokes Mortars.*—Various experimental work with the 3-in. Stokes mortar had been carried out, and all the sample brackets for the use of the mortar for anti-aircraft fire were evolved in the shops and sent to England. The anti-tank Stokes mortar mounting consisted of single man loads, and the gun could be fired at high and low angles at will. This mounting proved to be the only one of its kind produced, although many had attempted a solution of the problem; the difficulty being to make all the parts light enough to break up into single man loads.

*Final Percussion Grenade.*—The final effort of the Experimental Section was the evolution of the combined hand and rifle percussion grenade, started at the beginning of 1918. Three types of grenades were evolved, all on the same principle, but requiring different degrees of skilled manufacture. The final pattern, practically all the parts of which were pressed and stamped, was taken to the Second Army Headquarters at Cologne in February, 1919, and, after trial by three different Divisions and one Corps School, was very favourably reported on, and a recommendation was made that this type should be introduced into the Service in place of all other types of grenades, except the smoke grenade, and also that the smoke grenade should be fitted with a similar mechanism. The safety mechanism for this grenade consisted of a lever which only came off in flight if thrown by the hand or fired from the rifle, and with a 2-in. discharger the range obtained was about 350 yards, with considerably greater accuracy than any rodded type of grenade.

This practically terminated the history of the Experimental Section, and it was broken up in April, 1919.

It would be impossible to make a complete list of all the various articles experimented with and dealt with by the Section during the whole of its history, but it is safe to say that practically no device invented at home or in the Army in France connected with grenades, firework signals, and trench warfare weapons generally, did not at some period find its way to the Experimental Section for consideration or experiment, while many of the stores in regular use were actually initiated in the workshops.

In the following pages technical details are given of the evolution of the more important articles, with illustrations of the principal types designed or experimented with.

## Chapter 2.—Grenades.

The earliest hand grenades produced were of two types, the jam tin and the "hairbrush," both of which are illustrated (see *Plate* I, *Figs.* 1 and 2). A few of these were made, before the formation

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of the Experimental Section, by various field units. They were necessarily crude, and usually consisted of gun-cotton slabs and primers made up into the most suitable forms and fired by a detonator, with 5 secs. of safety fuze lit with a match.

At Arques, on the formation of the Experimental Section in October, a second and rather less crude form was produced, illustrated in *Fig.* 3. Splinters were introduced as much as possible amongst the high explosives, and tin cases were filled with fragments of iron, and in the " hairbrush " pattern pieces of scrap metal and nails were let in under the wire holding the gun-cotton slab in its place.

Some time before service grenades began to arrive in quantity from England a great demand arose, and the Battye, Pitcher, Bethune and No. 8 double cylinder hand grenades were manufactured in army and local workshops. The patterns were illustrated in *Notes on British, French and German grenades* (O.B./711 Confidential) issued in France in September, 1915.

Local contracts were also placed for manufacture of the Mills No. 5, which was in great demand after its introduction, but supplies of which were at first very slow in arriving from England.

During the summer of 1915, owing to the incessant demands for a rifle grenade that would outrange the ordinary throw of the hand grenade, troops of several Divisions put up suggestions and carried out experiments in firing the Mills from the rifle, and the Experimental Section developed what eventually became the No. 23 Mills rifle grenade (*Fig.* 4) with its cup attachment.

One of the original suggestions submitted to G.H.Q. consisted of simply fitting a clip to the bayonet, so that the lever of the Mills grenade was held in place until the grenade left the rifle. This necessitated placing the bomb in one particular way and was therefore not sound.

The cup attachment illustrated in *Plate* II, *Fig.* 1, produced by the Experimental Section, was adopted after trial by armies, and sent to England for manufacture in quantity. The attachment was stamped out of sheet iron, and bent round and welded, and was very simple to manufacture, and owing to its being in the form of a ring the grenade could be placed in any position with safety.

Attempts were made to devise a really safe percussion mechanism for a rifle grenade, and the Experimental Section produced two types, one of which was the conversion of the Mills No. 23 with a percussion mechanism (*Plate* II, *Fig.* 2), and another with a delay trail which rendered the grenade exceedingly safe to handle, as it did not arm until the trail had burnt away, after it had travelled some distance in its flight. This percussion rifle grenade, illustrated in *Plate* II, *Fig.* 3, had two steel balls which kept the striker pellet in place. On firing, the striker pellet, which carried the trail of black powder, set back on to another striker in the base of the grenade and started the

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trail burning. The trail burnt away in a few seconds, and on impact the balls were pushed into the holes left by the burnt-out trail, and the striker pellet was free to move forward and fire the cap.

Difficulties, however, were encountered in England in making a satisfactory delay trail of black powder, and this pattern was not manufactured.

The shortness of range obtained with the Mills percussion (*Plate* II, *Fig.* 2) did not give it any great advantage over the No. 23, but the mechanism was interesting. The lever acted as the safety device, and it prevented the striker, carrying the mushroom head, from firing the cap. When fired from the cup attachment on the rifle, and the safety pin removed, the lever flew off in flight, leaving the mushroom head free to move on impact. A balance spring was introduced below the main spring to prevent the mushroom head from setting back on shock of discharge and jamming the lever, and so preventing it from falling off. Also, as the grenade was fitted with an instantaneous fuze, a special cap holder was used to prevent the cap being fired by the flat striker of the ordinary Mills grenade, should the igniter set have been inadvertently placed in the No. 5 or No. 23 time grenades.

Prematures occurred at all times with all types of grenades, and the difficulty was to design a pattern that could easily be manufactured and which did not arm itself until it had left the rifle. The Newton was dangerous for this reason, but, after considerable experiment, a lighter cover was introduced, and various other safety devices were tried with it, but none of them were introduced for home manufacture. The Experimental Section fitted two clips under the cover, which were held in place by a collar setting back on shock of discharge and releasing the clips. This was an ingenious scheme, but the supplies of grenades from home were fitted with the light cover and a tin protective cover over the cap of the detonator sleeve, so that it could only be fired by a severe blow. Few, if any, prematures occurred with this type.

The Gauchet grenade (*Plate* III, *Fig.* 1) was given several tests and improved upon by the Experimental Section, but was by no means safe, and was given up, as was also the Sangster (*Plate* III, *Fig.* 2). The Hales No. 3 (service) rifle grenade was modified into a much improved pattern and the wind vane done away with. The grenade had simply a set-back collar releasing two pellets holding the striker, and was called the No. 20. The grenade was found satisfactory and supplied in large quantities, and, except for a few prematures which occurred, was safer than any other pattern. Manufacture was concentrated on it, and improvements were made which produced the No. 24 (*Plate* III, *Fig.* 3).

The cartridge used for the rifle grenades was at this time the cartridge supplied for the No. 3 Hales, and consisted of a blank

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round of 35 grains of $3\frac{3}{4}$ cordite. *Plate* IV shows this cartridge and the various developments from it. Owing chiefly to inferior cordite, the rifle grenade cartridge (35-grains) was not a complete success, and experiments were carried out in France by the Experimental Section to ascertain the cause of burst barrels and prematures that occurred with the Hales grenades.

In the case of burst barrels, the grenade frequently prematured as well, and the rod was found stuck in the barrel. The barrel after a few rounds began to bulge at a place opposite the end of the rod both with the No. 23 and Hales grenades, and in many cases the bulge eventually developed into a burst, unless detected in time. This was attributed to the gases impinging on the end of the rod, and if the rod was at all chamfered the bulge was considerably worse. To prevent this, gas checks on the end of the rod were tried. The ranges obtained, however, were so very erratic with grenades fitted with gas checks that they were abolished. *Plate* IV, *Figs.* 2 and 3, show two patterns used with the Newton (Second Army) grenades, the Adams pattern with the coned washer being the type made by the Experimental Section.

It was not until after considerable experiment that it was discovered that many of the failures of the barrels and prematures were due to the introduction by some manufacturers of a wax wad in the mouth of the cartridge. The first specification drawn up by the Ministry of Munitions showed that the mouth should be filled with varnished tallow. Some manufacturers used beeswax. The effect of firing the blank round with wax in the mouth was that the end of the rod received such a severe blow that it was set up; the grenade, then being propelled and armed, was suddenly checked owing to the setting up of the rod, causing the percussion mechanism, in the case of the Hales grenade, to function while still in the barrel.

Steps were taken immediately to stop the use of cartridges filled with wax and any further manufacture of them, and tallow was reverted to. Tallow, however, was not good, as it melted in the summer and affected the cordite, causing short rounds. It was not until the Munitions Design Department produced a paper cup pressed in to seal the cartridge that a cure was found, and by that time the 43-grain cartridge had been introduced, and all the 43-grain cartridges were sealed in this way (*Plate* IV, *Fig.* 4).

A 43-grain cartridge, filled with tallow, appeared during 1916 with the object of improving the degree of cordite, but was no great improvement on the 35-grain.

The advent of the paper wad for filling the mouth of the cartridge, in the summer of 1917, gave the first cartridge which was suitable for use with all types of grenades. The 43-grain used a thicker and better brand of cordite—$4\frac{3}{4}$—and was slower burning, and suited all grenades except the Hales. The set-back collar of the Hales No. 20

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and No. 24 did not always function with the 10 in. rod, and the No. 35 was fitted with an easier fitting collar accordingly.

With the long rodded Newton grenades, the 35-grain was unsatisfactory, as the rate of burning was high, and owing to the small chamber space left by the long rod the temperature set up was too great and caused the casing to be brazed to the barrel. In these grenades, therefore, the ordinary bulleted round cartridge with the bullet removed and filled with tallow was employed. This cartridge used with short rods was a danger and unsatisfactory, as, owing to the long chamber space, the cordite did not always burn through in time and blew up the barrel, causing short rounds with the No. 23 Mills.

The Experimental Section took a big part in the development of these cartridges, and it was to a great extent owing to their experiments that the causes of defects were found and a universal cartridge introduced.

Above all types of grenades the Mills was supplied in the largest quantities, and experiments were continually carried out to improve it, and to investigate various accidents that occurred from time to time. Locally made Mills grenades were not in many cases successful, and were condemned by the G.H.Q. Board. Prematures frequently occurred with the Mills, and for a long time the causes were not clear, owing chiefly to the difficulty of getting particulars.

All accidents were reported to G.H.Q. and investigated technically for the period of the whole War by the O.C. of the Experimental Section and, as a result of experiments, one great cause of failures was found, *viz.*, that the gases from the burning fuze could not escape easily enough when the cap had been fired. A central fire cap was used and, although the cap holder had holes in it for gases to escape from the fuze, the striker and spring blocked most of the passage way. The Experimental Section then devised the rim fire cap, and a slotted striker, so that the gases blew up the centre of the cap, out past the slot in the striker, and then up the central passage past the spring. Frequently accidents occurred from the striker slipping out through the jaws of the lever while it was still in hand. If the thrower then lost his head the grenade would go off in the hand. The striker introduced into the No. 36 Mills grenade prevented any possible failure from this cause, and the Mills of the last period of the War, thanks greatly to the work of the Experimental Section, was as safe a grenade as its design permitted it to be.

Prematures still occasionally occurred when fired from the rifle even in 1918, and this could only be attributed to bad crimping of the fuze, so that, on shock of discharge, the fulminate in the detonator set back on to the end of the fuze and detonated. Only careful manufacture and inspection could avoid this cause of danger, as owing to the design of the grenade, it could not be altered.

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During 1916, the Newton No. 22, Mills Nos. 5 and 23, and Hales Nos. 20 and 24 were the patterns mostly used, and during this period the Experimental Section occupied considerable time in investigation and working on improvements of these grenades and experimental patterns, and also in the production of a good cartridge.

About Christmas, 1916, the French invention of a discharger cup fitted to the rifle opened up a new era in the experimental work on grenades. The grenade had a hole in it and was fired by a bulleted round. Attempts were at once made to fit a similar discharger to the short M.L.E. rifle. The best fitting of its type was produced by the M.I.D. in London, illustrated in *Plate* V, *Fig.* 1, and was introduced into the Service in the summer of 1917. Experiments were then concentrated on the design of a gas-port for this discharger. It was decided to use the Mills grenade and not a special pattern similar to the French. Experiments were carried out, and trials showed that a plain disc was more suitable and gave more accurate results and greater ranges than with a ring cast on the body of the grenade, or than a flanged gas check for firing the grenade (*Plate* V, *Fig.* 2). The Mills was then given a 7-secs. fuze, had a range of 200 yards, and was known as the No. 36 grenade. A suitable gas-port was evolved for varying the ranges, and in May, 1917, was sent to England to the Ministry of Munitions, where it was used as a guide in manufacture.

The introduction of the cup discharger necessitated experiments being undertaken to produce another cartridge, as different conditions were set up in the barrel. The cordite cartridge was too slow in burning to develop pressure rapidly enough to eject the grenade with any degree of consistency, and only one pattern of 35-grain cartridge, manufactured by Messrs. Eley Bros., gave anything like fair results, the other 35-grain cartridges and particularly the 43-grain being useless for the purpose.

A cartridge containing 30-grains of ballistite was therefore introduced for the purpose and is illustrated on *Plate* IV, *Fig.* 5. This cartridge had its case bronzed for the top half of its length, while the 43-grain, to distinguish it from all others, was completely bronzed.

The use of the discharger naturally opened up a new field of investigation for grenades, especially as regards the "Always" type of percussion hand grenades. A grenade of this nature, which should be both safe in use and simple in manufacture, provided much food for thought.

It was clearly an advantage if the hand percussion grenade with an "Always" mechanism, which would fire in whatever position it fell, could also be used with the discharger, so that the same grenade might be used for both purposes.

The first percussion hand grenade to be sent out to France and tested was the R.L. percussion grenade, but at that time, 1916, this was not safe enough, although it developed later into the Humphries and

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C.S.O.F. patterns. The No. 19, which was a percussion with a mushroom head but not an "Always" fuze, was not satisfactory, and, although more scientific as regards its fragmentation and functioning mechanism, was not a great advance on the No. 1.

Experiments were put in hand to develop a suitable "Always" percussion mechanism, in accordance with the following conditions:

PERCUSSION GRENADES.

*Essential.*

(1) The grenade must be damp-proof.
(2) The grenade must be capable of withstanding rough usage, and its action must not be impaired by mud.
(3) The grenade must be furnished with a positive safety device, such as a safety pin.
(4) The grenade must only arm itself in flight, and must be safe when dropped on the ground, the safety device having been removed.
(5) The grenade must be safe when held in the hand after the safety device has been removed.
(6) The grenade, having armed, must be sufficiently sensitive to function on impact with soft mud.
(7) The fragmentation must be satisfactory.

*Desirable.*

(1) It should be capable of being used as a hand or rifle grenade.
(2) The weight should not exceed 1½ lbs. and the design should be such that smaller sizes down to 12 ozs. can be made.
(3) The shape should be convenient for throwing.
(4) It should not have stick or streamers, nor should it be necessary to throw it in any particular way.
(5) "Blinds" should be safe to handle with reasonable precautions.

After much trial and experiment with various types, a pattern was evolved in the experimental workshops which was simple to manufacture and which gave very promising results (*Plate* VI).

The first pattern of the kind was sent to England in January, 1918, for 1,000 to be made for trial, and experiments were continued to improve its simplicity from the manufacturing point of view. The mechanism thus developed is illustrated in *Plate* VII and it was further developed by the Experimental Section into the "B" pattern illustrated in *Plate* VIII.

This latter grenade was made of parts nearly all stamped out and pressed from sheets, and with a 2-in. diameter discharger a range of 350 yards was obtainable. The safety device was the greatest problem of all, as the tape used in the "A" pattern was never

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considered favourably. The lever evolved and introduced into the "B" type met with great success and, in November, 1918, 200 of the Bellamy "A," which had eventually been manufactured by the Ministry of Munitions, and five other types were tested in comparison. Of these, the two types of Bellamy and one known as the C.S.O.F. were selected in preference to two others—the Vickery and Coles. 2,000 of each of these three were demanded from home for trial by troops, but after the Armistice no further experimental contracts were placed in England. In order, however, to get a practical opinion on the question of percussion grenades, the two types available in France, the Bellamy "A" and "B," were shown to the Second Army at Cologne, who recommended that the "B" pattern with lever should replace *all* other types of grenades in use except the smoke grenade, and this opinion was endorsed by the General Staff and communicated to the War Office accordingly.

This closed the history of development of the percussion grenade with which the Experimental Section had been so long and closely connected.

The Bellamy grenade was so safe that it could be shaken and carelessly handled, or rolled on the ground, without danger, even with the safety lever off, and yet was sufficiently sensitive to go off if lobbed over a parapet on to soft soil. All other patterns were very much more sensitive, and a more sensitive grenade did not appeal to the troops asked to give these grenades a trial.

The Experimental Section was called upon to test various other types, including the Humphries grenade in June, 1917, and the Chamier in June, 1918.

The Chamier was highly dangerous, but the Humphries developed into the C.S.O.F. referred to previously.

Suggestions were made in 1917, to alter the range of grenades by means of allowing different lengths of rod to protrude from the barrel, and *Plate* IX shows a method devised in the XIII Corps with the Newton grenade.

The Experimental Section in July, 1917, carried out experiments on these lines and rubber was used in the form of a ring slipped over the rod. The rubber ring was simply stamped out of sheets of inner tube of a motor car tyre, and was quite satisfactory. This method was adopted, and range cards made out for use with the rings, and supplied to the troops in 1918. This method of altering the range was, of course, only suitable for trench warfare, and after the introduction of the discharger and No. 36 grenade little use was made of the device.

Several suggestions were submitted from time to time for the use of clinometers when firing grenades, but the general opinion was that the long rodded rifle grenades were not nearly accurate enough to warrant the introduction of such refinements. A simple clino-

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meter was evolved in the workshop but was never introduced, as the demand was small. The rubber rings were considered a better method of altering ranges than altering the elevation, as low angles could not easily be got in a trench without exposure, and high angles made the flight still more erratic. With the No. 36 the gas-port met the case, and even then a clinometer to regulate the fixed angle of 45° was not called for, as the rifle could be held after practice at very nearly the correct angle—in any case sufficiently correct in relation to the accuracy of the grenade itself.

A complete history of grenades needs a volume to itself. All that has been attempted here is to describe and illustrate the types actually experimented with and developed by the Section in the course of work which had a considerable share in, and influence on, the evolution of the grenade.

The anti-tank grenade is described later under "Anti-tank Defence Weapons."

Appended will be found a list of all the service grenades and signals to which series numbers were given, and a table of ranges of rifle grenades.

RANGES.

| *Grenade.* | *Length of Rod.* | *Ranges.* |
|---|---|---|
| No. 24. | 15 in. | 360 yards with 43-grain cartridge. |
| | | 345 ,, ,, 35 ,, ,, |
| ,, 35. | 15 in. | 350 ,, ,, 43 ,, ,, |
| | 11 in. | 260 ,, ,, 35 ,, ,, |
| | 11 in. | 270 ,, ,, 43 ,, ,, |
| ,, 39. | 11 in. | 260 ,, ,, 43 ,, ,, |
| | 15 in. | 330 ,, ,, 43 ,, ,, |
| ,, 22. | 15 in. | 340 ,, unbulleted. |
| ,, 27. | 15 in. | 250 yards with 35-grain cartridge. |
| | | 260 ,, ,, 43 ,, ,, |
| | | *Open.* Yds. / *Shut.* Yds. |
| ,, 37. | Cup. | 100 / 250 |
| ,, 36. | Cup. | 80 / 210 |
| ,, 23. | Cup attachment. | 100 yards with 35-grain cartridge. |

GRENADES AND SIGNALS.

*No.*

1. Service, Hand, R.L. Percussion—Cane Handle.
2. Tonite or Mexican (Hales Percussion with cane handle).
3. Hales Rifle (J.A. pattern) with Vane.
4. ——
5. Mills, Hand.
6. R.L. 1 lb. friction igniter, hand.
7. R.L. 2 lb. ,, ,, ,,

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*No.*

8. Double Cylinder, light patt. (No. 8 Detonator), shrapnel bullets in tin container.
9. Double Cylinder, heavy patt. (No. 8 Detonator), shrapnel bullets in tin container.
10. ——
11. ——
12. " Hairbrush " or Box Pattern, wood handle, No. 8 Detonator, Spring Striker.
13. ——
14. Battye.
15. Pitcher.
16. Oval.
17. Ball.
18. ——
19. Mushroom Percussion Grenade.
20. Hales Vaneless Rifle (long tube).
21. Newton Pippin Rifle Percussion.
22. ,, ,, ,, ,, Mark I and II.
23. Mills No. 5 and Rod—Rifle.
24. Hales Vaneless No. 20 modified—Mk. I modified known as Mk. II, Mk. II known as No. 35 Mk. I.
25. ——
26. " P " Bomb—Red Phosphorus.
27. Phosphorus, white, rifle and hand.
28. Gas Bombs, M.S.K.
29. ——
30. ——
31. Signal Rifle Grenade, Rod (Day).
32. Signal Rifle Grenade, Rod (Night).
33. Hilite.
34. Egg Bomb, Mark III.
35. Hales No. 24 Mk. II—Mk. I.
36. Mills No. 23 with disc for Discharger.
37. No. 27 for Discharger.
38. Signal Rifle Grenade, Rod, Changing Colour.
39. Steuart Fuze Rifle Grenade.
40. ——
41. ——
42. Smoke Parachute Discharger Signal.
43. 3-Star Parachute Discharger Signal.
44. Anti-tank Grenade.
45. Changing Colour Parachute Discharger Signal
46. ——
47. ——
48. ——

(*To be continued.*)

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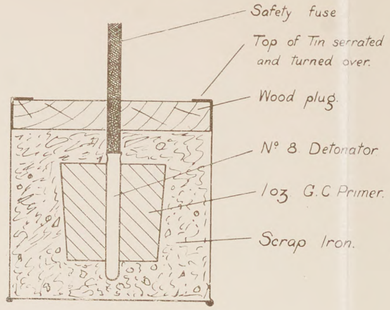
Fig. 1.

JAM TIN HAND GRENADE
MADE ON THE AISNE, 1914.




STICK HAND GRENADE
MADE AT ARQUES.—November, 1914

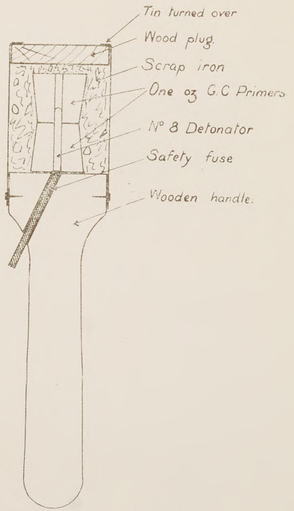



Fig. 3

Fig. 2.

STICK HAND GRENADE MADE
ON THE AISNE.—September, 1914

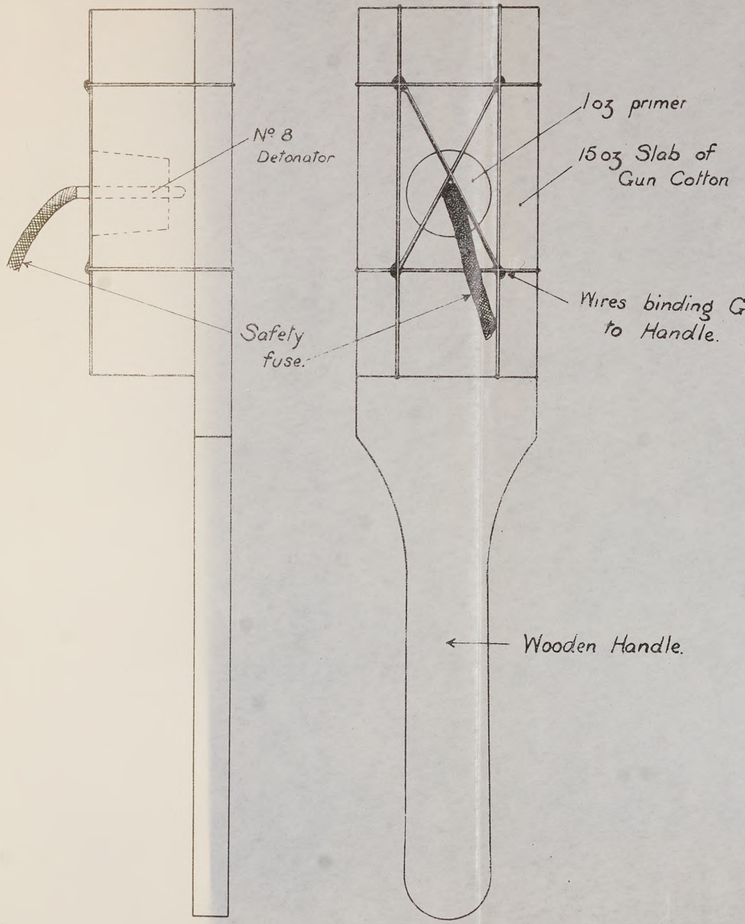



Fig. 4.

PLATE I.

MILLS RIFLE GRENADE.

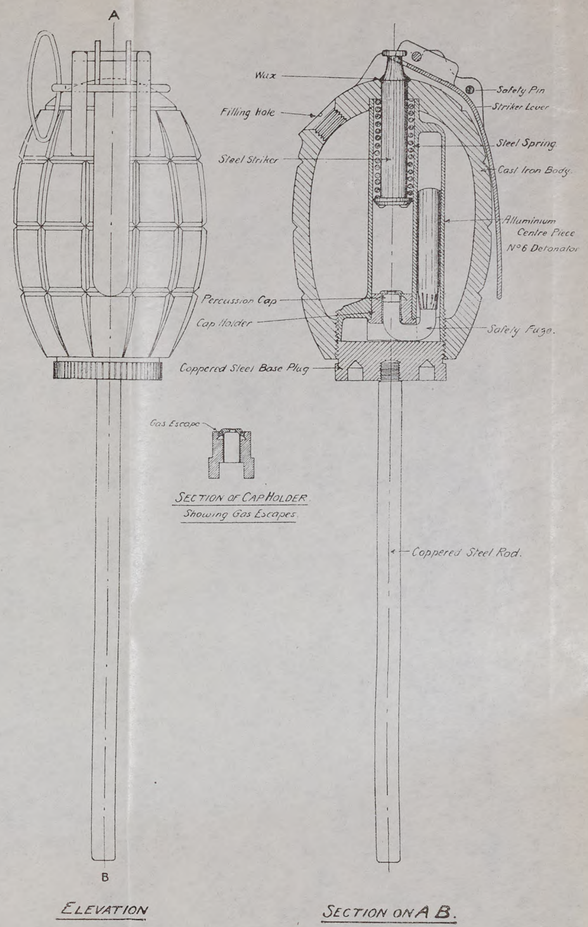



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Fig. 1.

ATTACHMENTS FOR GRENADE MILLS, No. 23, Mk. II. (WITH ROD).

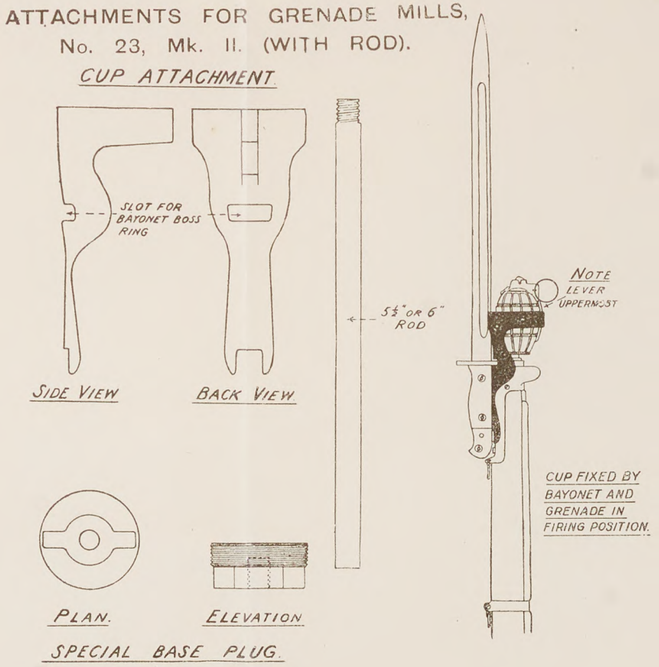


Fig. 2.

ADAMS EXPERIMENTAL PERCUSSION MILLS RIFLE GRENADE ST. OMER, 1915.

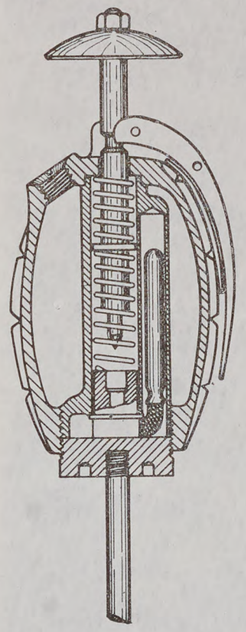

Fig. 3.

ADAMS EXPERIMENTAL PERCUSSION RIFLE GRENADE. ST. OMER, 1915.

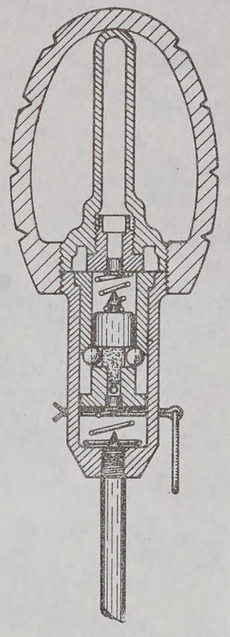

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Fig. 1.
GAUCHET GRENADE.

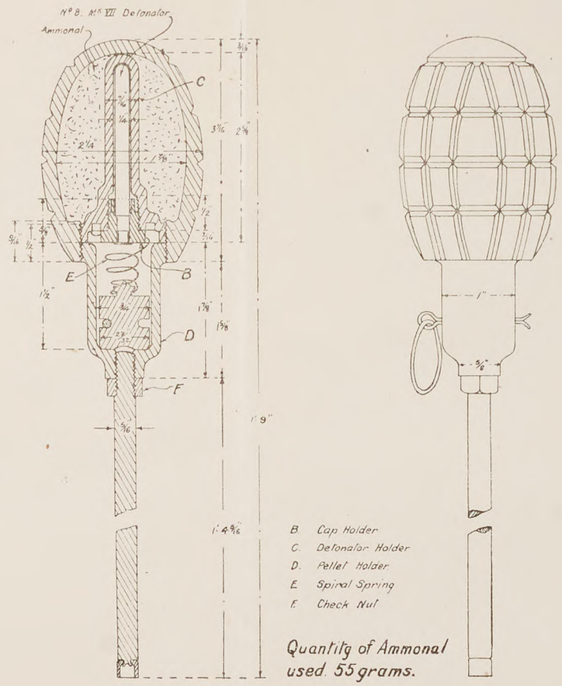



Fig. 2.
SANGSTER RIFLE GRENADE.

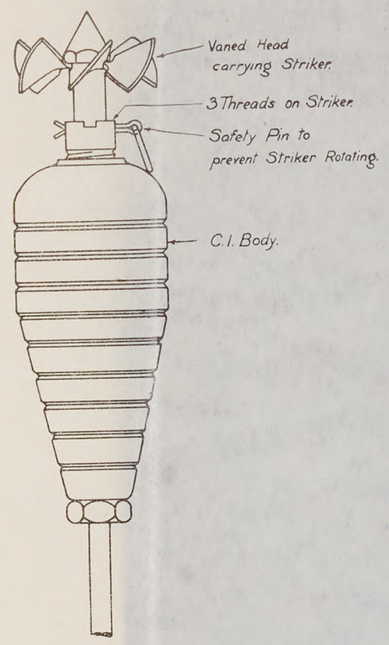
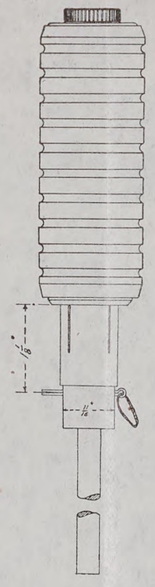
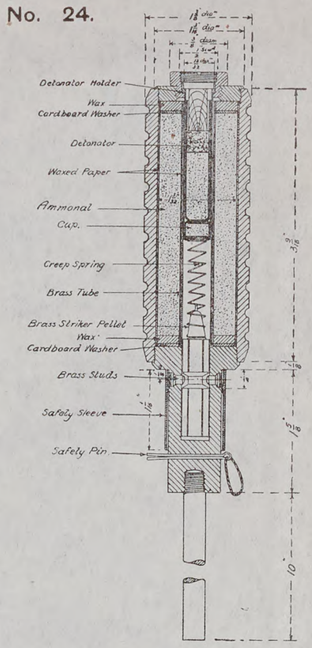



Fig. 3.
RIFLE GRENADE.
No. 24.


ELEVATION



SECTION

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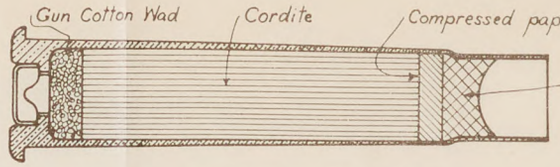
PLATE IV.

Fig. 1.




UNBULLETED ROUND.

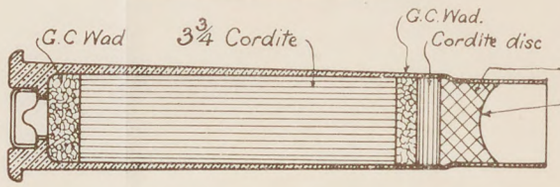
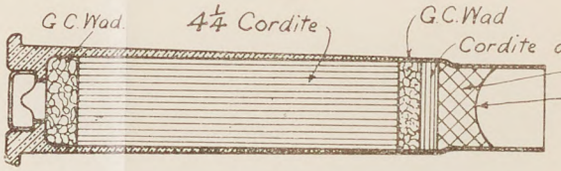
Fig. 2.

35 GRAIN.

Fig 3.




NEW 43 GR. (BRONZED, FULL BLACK CASE.)

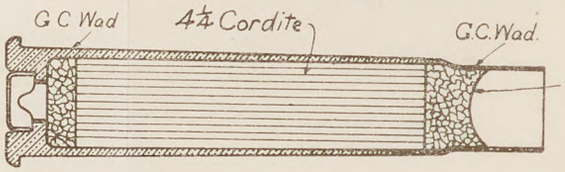
Fig. 4.

NEW 43 GR. (BRONZED FULL CASE.)

Fig. 5.

30 GR. BALLISTITE. (BRONZED HALF CASE.)

GAS CHECKS FOR RODS
FOR NEWTON RIFLE GRENADES.

Fig. 6.

ADAMS PATTERN

Fig. 7.

NEWTON PATTERN

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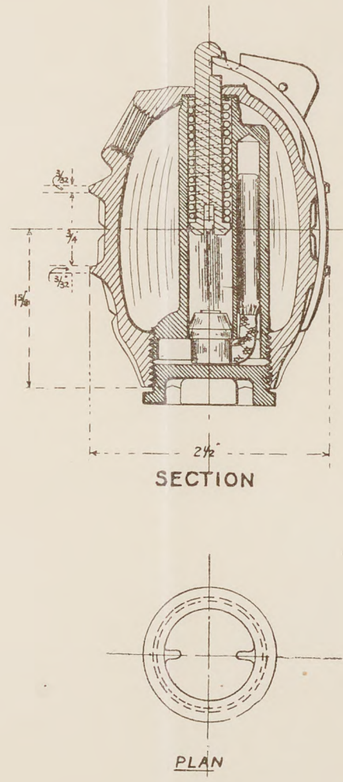
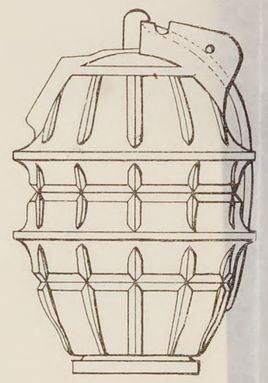
Fig. 1.

COMBINED MILLS HAND OR RIFLE GRENADE

FOR USE WITH DISCHARGER.




SECTION



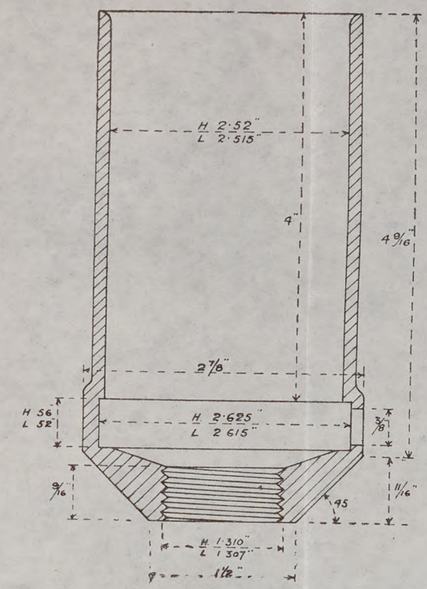
ELEVATION

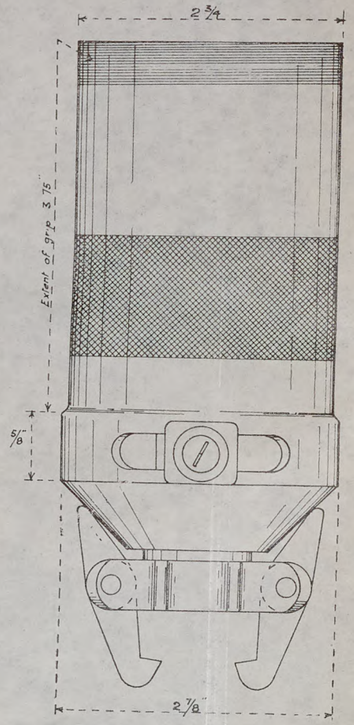


PLAN

Fig. 2.

DISCHARGER. No. 1. MARK I.

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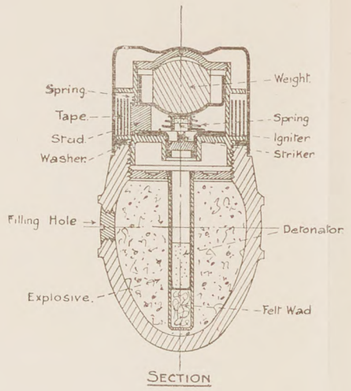
# PLATE VI.

## EGG PERCUSSION BOMB.

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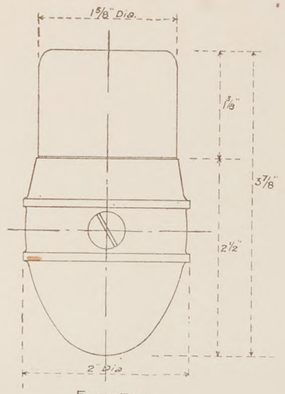
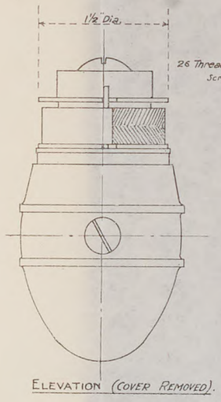
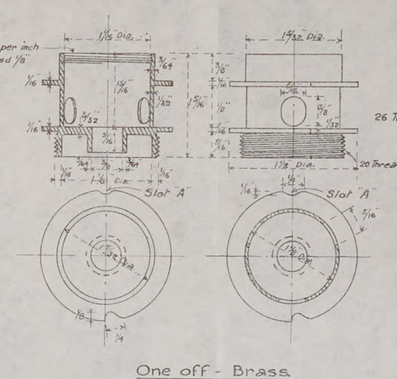


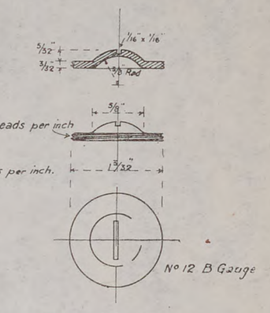

ELEVATION.



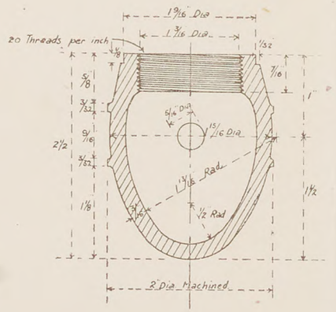

ELEVATION (COVER REMOVED).

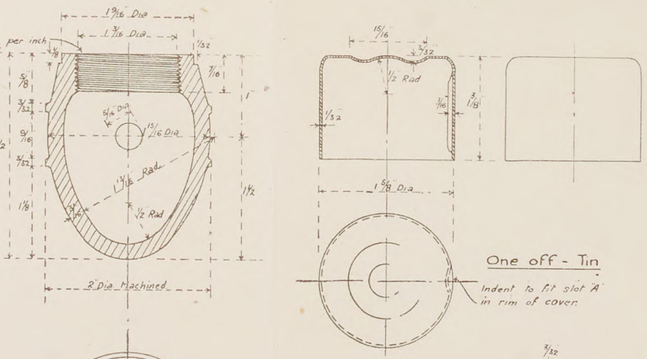



One off - Brass



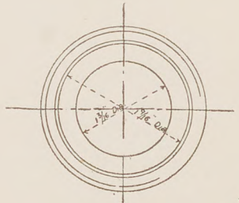

One off - Brass



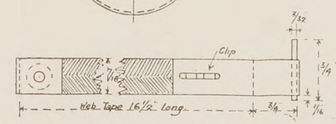




One off - Tin

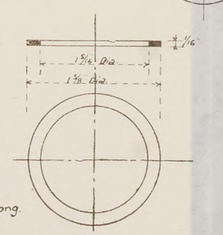
Indent to fit slot 'A' in rim of cover.



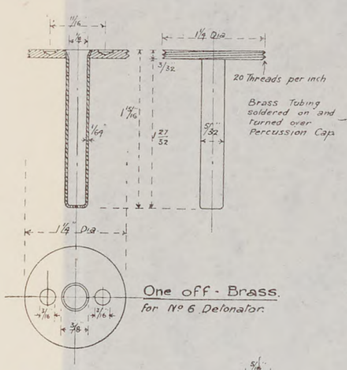

One off - Cast Iron.



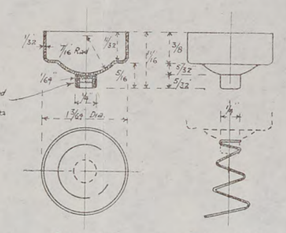
One off.




One off - Leather.

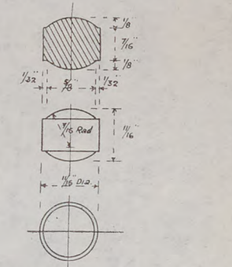



One off - Brass.
for No 6 Detonator.

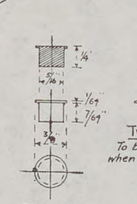



One off -
Steel Coppered.

One off
To be quite flat when compressed

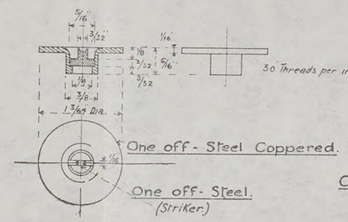



One off - Lead



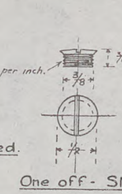

Two off -
Brass.

Two off.
To be quite flat when compressed.




One off - Steel Coppered.

One off - Steel.
(Striker)




One off - Steel.

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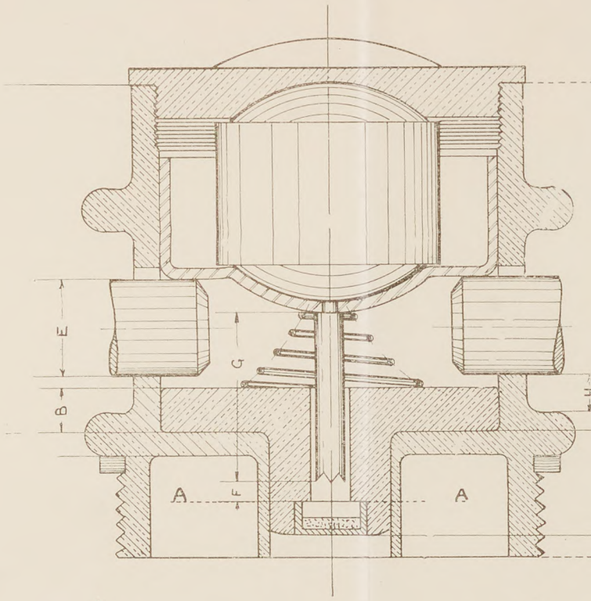
# 'BELLAMY A" TYPE PERCUSSION GRENADE.

## A

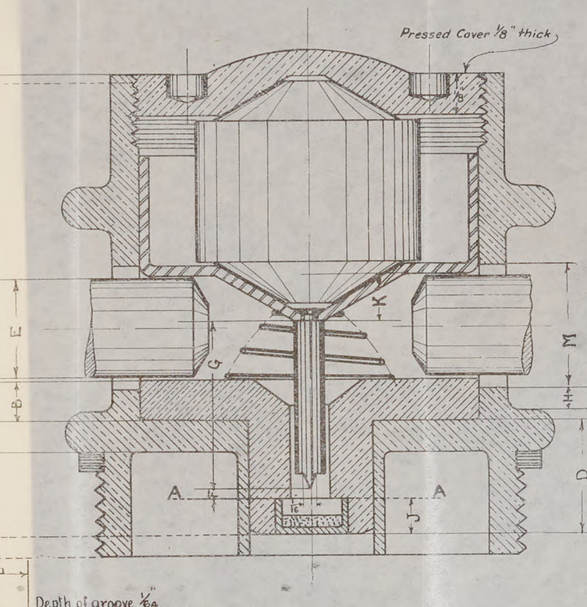
### SECTION OF GRENADE AS MADE.

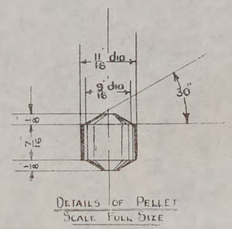



| | | |
|---|---|---|
| A | Depth of Chamber — 1 1/16" | |
| B | Thickness of flange on cap holder. — 9/64 | |
| C | Thickness of base of chamber. — 1/16 | |
| D | Length of projection carrying cap. — 5/16" | |
| E | Diameter of Safety pins — .305" | Length = 7/32" |
| F | Point of striker to edge of cap — 1/16 | |
| G | Length of striker. — 33/64. | |
| H | Edge of hole above flange — 7/64" | |

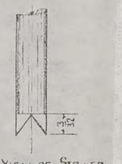
## B

### SECTION OF GRENADE SHEWING NECESSARY MODIFICATIONS.




DETAILS OF PELLET
SCALE FULL SIZE




SIDE VIEW OF STRIKER

MANDREL for winding spring

| | | |
|---|---|---|
| A | Depth of Chamber. — 1 1/16 | |
| B | Thickness of flange on cap holder. — 1/8 | |
| C | Thickness of base of chamber. — 1/32 | |
| D | Length of projection carrying cap — 1/2 | |
| E | Diameter of Safety pins. — 5/16 | Length = 9/32 ( 1/16 longer than shewn in Section A. |
| F | Point of Striker to edge of cap — 1/32 | |
| G | Length of Striker. — 33/64. | |
| H | Edge of hole above flange — 1/16 | |
| J | Depth of recess holding cap — 7/64 | |
| K | Height of cone — 9/64 | |
| L | Base of chamber below flange — 1/32 | |
| M | Depth of pin holes — 3/8 Width 21/64 | |

Steel Striker Spring.

Inside dia of top 1/8
Inside dia of bottom 1/2
free length 1/2
No of free coils 2
To compress 13/32 with a load of 2 2 ozs

Experimental Branch
R in C 23 12 18

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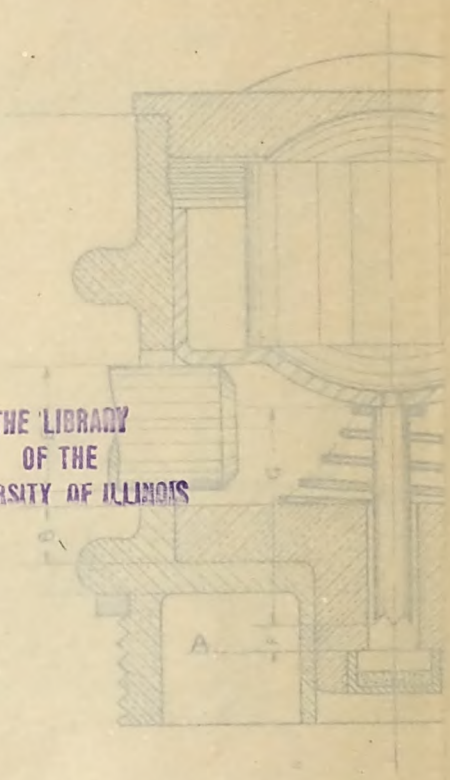
A

SECTION OF GRENA

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A Depth of Chamber — 1½
B Thickness of flange on cap holder
C Thickness of base of chamber —
D Length of projection carrying c
E Diameter of Safety pins — 3
F Point of striker to edge of cap
G Length of striker. — 2¼
H Edge of hole above flange —

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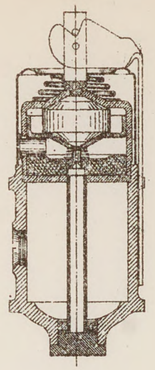
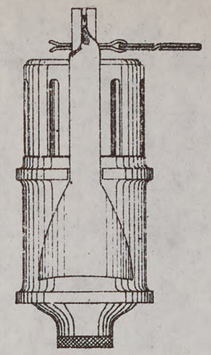
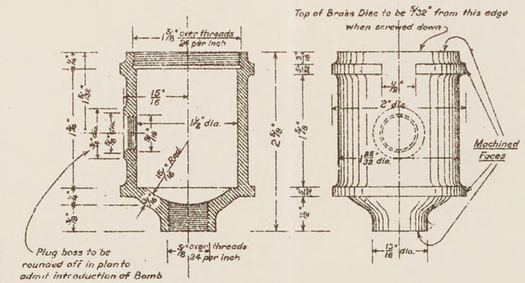
# BELLAMY 'B' TYPE PERCUSSION GRENADE

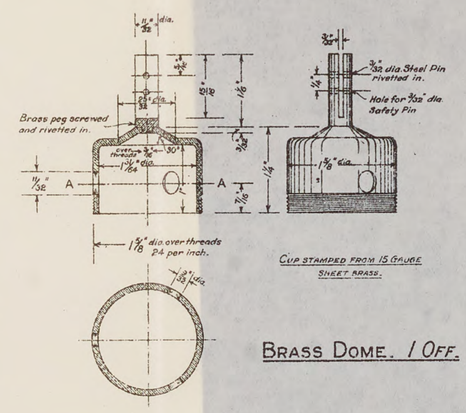
PLATE VIII.





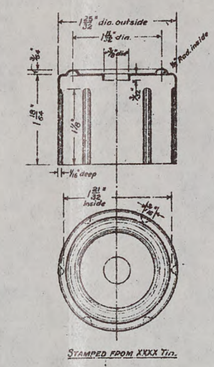

Top of Brass Disc to be 5/32" from this edge when screwed down
5/8" over threads 24 per inch
15/16"
1 1/8" dia.
2 5/8"
1 1/16"
2" dia.
Machined Faces
Plug boss to be rounded off in plan to admit introduction of Bomb into Discharger.
7/8" over threads 24 per inch.
1 1/2" dia.

CAST IRON BODY. 1 OFF.


Brass peg screwed and rivetted in.
3/32 dia. Steel Pin rivetted in.
Hole for 3/32" dia. Safety Pin
1 5/8" dia. over threads 24 per inch.
1 5/8" dia.

CUP STAMPED FROM 15 GAUGE SHEET BRASS.

BRASS DOME. 1 OFF.



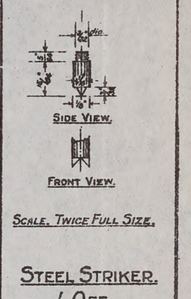

STAMPED FROM XXXX Tin.

COVER. 1 OFF.

STRIKER SPRING. 1 OFF.

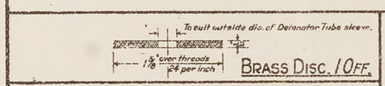



STEEL PLUG. 1 OFF.

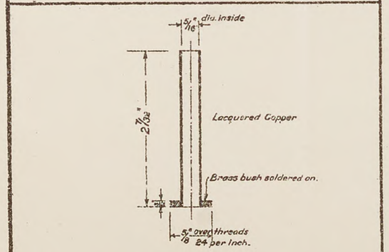



SCALE. TWICE FULL SIZE.

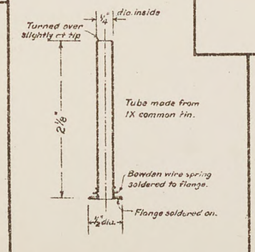
STEEL STRIKER. 1 OFF.



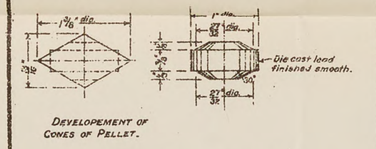

BRASS DISC. 1 OFF.




SLEEVE FOR DETONATOR TUBE. 1 OFF.

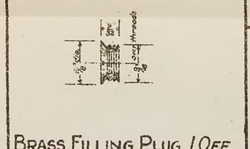



DETONATOR TUBE. 1 OFF.

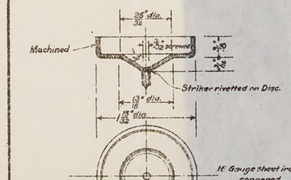



DEVELOPEMENT OF CONES OF PELLET.

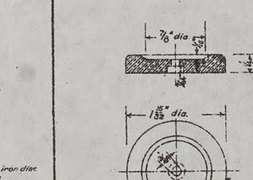
LEAD PELLET. 1 OFF.



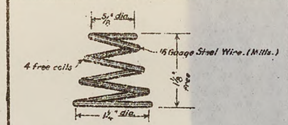

BRASS FILLING PLUG. 1 OFF.



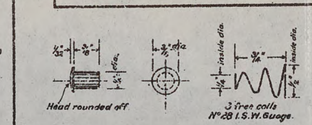

STRIKER DISC. 1 OFF.



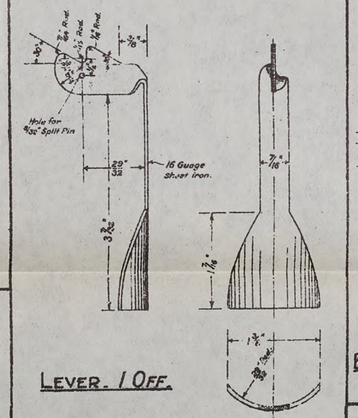

DISC CARRYING CAP. 1 OFF.



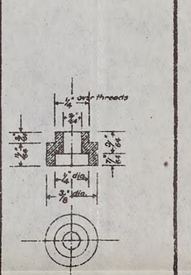

COVER SPRING. 1 OFF.




STEEL PIN & SPRINGS. 3 OFF.




LEVER. 1 OFF.




SCALE. TWICE FULL SIZE.

BRASS CAP HOLDER. 1 OFF. (NOT REQ?)

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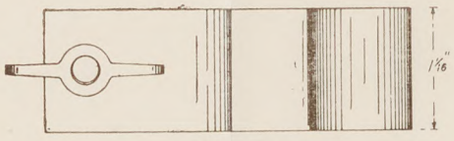
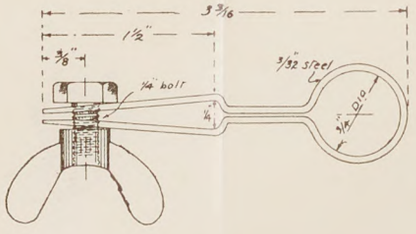
# RANGING DEVICE FOR NEWTON PIPPIN RIFLE GRENADE.

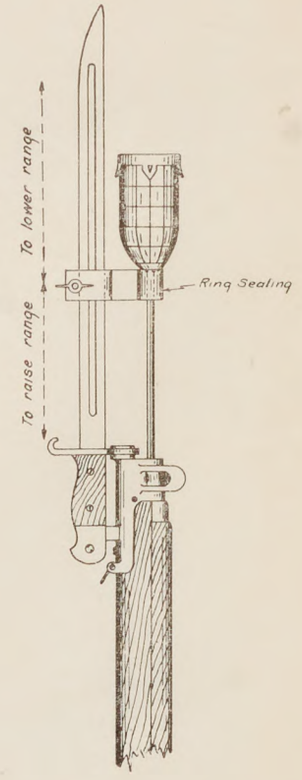
(XIIIth CORPS)




ELEVATION




PLAN

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# *HISTORY OF THE 12th COMPANY ROYAL ENGINEERS.*

*(Continued.)*

*By* LIEUT. M. R. CALDWELL, R.E.

THE Company remained in Komatie Poort until December 23rd, 1900, Major Graham Thomson becoming C.R.E. and Commandant Komatie Poort, as the C.R.E. (Lieut.-Colonel Foley) had proceeded home. The Company, meanwhile, carried out road-making, laying extra railway sidings and building platforms for new camps, hutting both for camps and hospitals, and water-supply. Much of the hutting was done by contractors and supervised by the Company. Several detachments were also out, carrying on much the same work.

The Komatie valley was a most unhealthy spot and nearly everyone in the Company was down with malaria sooner or later, some very badly, as will be seen from Appendix IIA. The animals, too, found the climate no more congenial and losses among them were very heavy, as is shown in Appendix IIB.

On October 10th Lieut. Pollard and the Newcastle Volunteers left the Company and proceeded to Pretoria.

On December 11th Captain Craven and 40 rank and file left for Barberton.

*Move to Barberton.*—On December 23rd the Headquarters of the 12th Company, consisting of one officer and 49 rank and file, moved to Kaapmuiden, where hutting was carried on for a week, the Company moving to Barberton, where Captain Craven's detachment was rejoined on the 3rd January.

On arrival at Avoca, *en route* for Barberton, it was found that the river was in flood and that the deviation had been washed away. Consequently nearly everything, including tool-carts, had to be transported across by an aerial line. This occupied two days (1st and 2nd January), the Company reaching Barberton the next day.

Here work was carried on on defences of all types, obstacles and land-mines, as well as defences being erected at Kaapmuiden, Hector's Spruit and Malalene.

The Company remained at Barberton until September, 1901, during which time various detachments were out, Kaapmuiden, Hector's Spruit, Malalene, Machadorp and Avoca being the chief.

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*Blockhouse Construction.*—The Company, on arrival at Barberton, settled down to the construction of blockhouses, which became such a salient feature of the defences along the railways and at bridges and river-crossings for the " drives " or " round-ups " in the latter part of the war. A very large number of these blockhouses were built along the line from Komatie to Kaapmuiden and Barberton, and a considerable amount of work was done in erecting barbed-wire entanglements between them.

A very large amount of work was also carried out on hutments for barracks, hospitals and stables, as well as several diamond-drill borings.

The work during this period was very arduous, owing to the trying climatic conditions, malaria being even more prevalent than at Komatie.

There were also several small brushes with the enemy in the neighbourhood, and several alarms and " stand-to-arms," although the Company was never seriously engaged during this time. During this period Lieut.-Colonel Graham Thomson had been C.R.E., Barberton district.

However, on September 19th, 1901, the Company quitted the Barberton district after almost exactly a year, and were seen off by the G.O.C. (Major-General Stephenson), who made a speech to the men, expressing his appreciation of the work done while in the district.

The following letter was also received the day previous to leaving:—

To :—

Major Graham Thomson, N.C.O.'s and Men of the 12th Co., R.E.

General Stephenson wishes to express his sincere regret at parting with the 12th Co., R.E. Although from previous association in the 11th Division he was fully aware of their high reputation, and had many opportunities of noticing their excellent spirit throughout the long marches from Bloemfontein to the Kapp valley, it is only during the past year that he has learnt to specially appreciate the soldierly smartness and devotion to duty of all ranks under very trying circumstances. The Engineer duties in this District have been extremely arduous and, owing to the prevalence of malaria, have had to be carried out under dangerous climatic conditions, yet the G.O.C. has never heard a word of complaint; both officers and men have shown a splendid spirit in sticking to their duty in spite of illness, and their ready resource and the thoroughness of their work have made the Barberton District probably the best-fortified in the whole Transvaal. In bidding good-bye to the 12th Co., R.E., General Stephenson ventures to wish all ranks the highest success, and a happy time under more healthy conditions in their new District.

(Sgd.) T. E. STEPHENSON, *Major-General,*
Commanding Barberton District.

Barberton,
18/9/1901.

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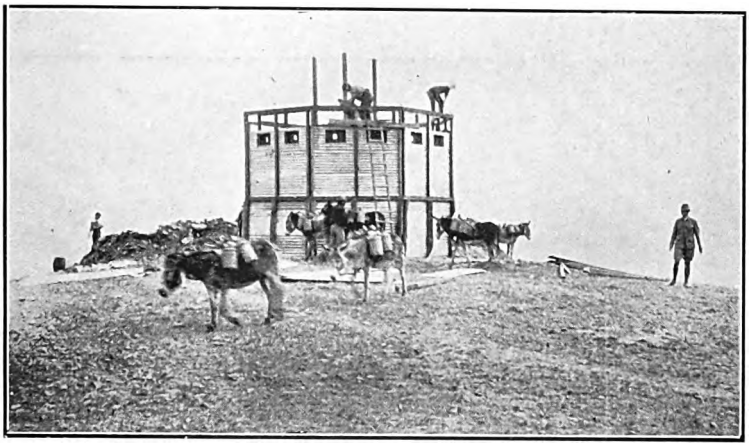
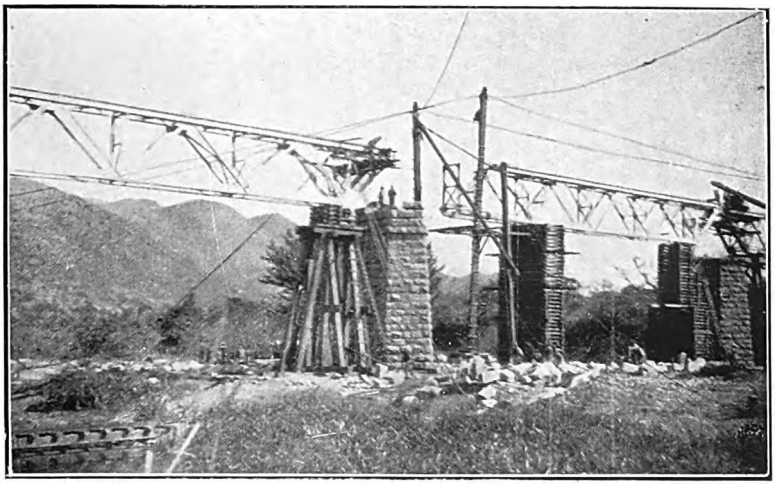
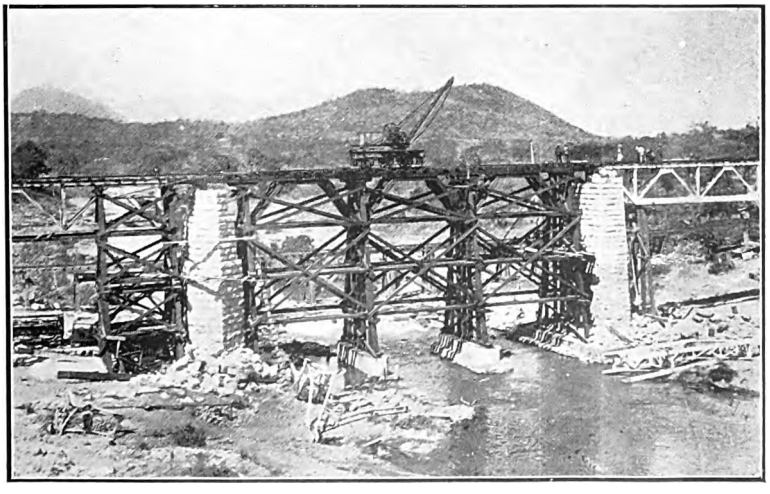
# HISTORY OF THE 12TH COMPANY, ROYAL ENGINEERS.



Blockhouse building near Barberton.





Repair of Bridge at Hector's Spruit.

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*Harrismith.*—Travelling by train *via* Waterval Boven, Pretoria, Elandsfontein, Standerton and Ladysmith, they arrived at Harrismith about 4 p.m. on the 24th. A small party under Captain Craven was left at Barberton to hand over to the 5th Company from whom the work at Harrismith was taken over. This detachment proceeded to Brandwater Basin on the 9th October.

On the 25th September a small detachment under Lieut. Nation left to join Colonel Vizard's Column, and proceeded to Olivers Hoek, where work on water supply and blockhouses was carried on until the 1st December, when the party returned to Harrismith.

The work while at Harrismith was chiefly blockhousing and other defence work on the line Van Reenans–Harrismith–Bethlehem–Basuto border; in all, about 60 miles. Between October, 1901, and the end of March, 1902, some 432 blockhouses were erected. A large amount of wiring was also done between the blockhouses and several sangars and redoubts were also built.

*Tweefontein Disaster.*—Several of the detachments came in for brushes with the enemy, one, which was with General Rundle's force blockhousing near Tweefontein, coming in for a fight on Christmas Day, 1901, when the Yeomanry camp was rushed by a strong party of Boers at 2 a.m., some 6 officers and 50 other ranks being killed and 60 wounded, and several pompoms and waggons lost. Several blockhouses south of Bethlehem were destroyed, but were very soon replaced by nearly double the number. Again in January several casualties were caused by snipers, who all the time continued to frequent the neighbourhood, among the casualties being two of the Company mules which were killed at Tiger's Kloof.

In spite of this, however, the blockhousing went on as fast as it could be pushed, and the following was received from Headquarters, Harrismith District:—

*Copy of Telegram.*

*From* C.R.E. Army.
*To* G.O.C. Elands River Bridge.

D.5136. 21st Jan. Progress of Blockhouses to Bethlehem has been very satisfactory.

---

*To* C.R.E.

The Lieut.-General, in communicating the attached telegram from the C.R.E. of the Army, desires at the same time to place on record the good and untiring work done by Lieut.-Col. Graham Thomson and the 12th Company R.E. since they have been in this district.

(Sgd.) L. E. KIGGELL, *Lieut.-Colonel*,
A.A.G. Harrismith District.

Elands River Bridge,
22nd January, 1902.

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On March 14th two of the native boys employed by the Company were seriously wounded in an attack on Fort Davidson.

During March a considerable amount of damage was caused to bridges and drifts by the rivers flooding. A collapsible and portable boat was found most useful on these occasions, a ferry being formed with its help on April 1st, when the 14th Hussars and a regiment of Yeomanry were taken across Elands River at Majoors Drift by Lieut. Nation's detachment.

During the month Captain Craven's section was constantly under fire during the construction of the Brindisi-Bethlehem line of block-houses. A large amount of hutting was also erected in the Harri-smith district, mainly for hospitals, remount depôts and veterinary hospitals.

*Peace Signed.*—On May 31st, 1902, Peace was signed at Pretoria, the official announcement reaching the Company next day.

On June 3rd, Corporals Allardyce and Shaddick were sent home as unit representatives in the forthcoming Coronation reviews, etc.

During the month work was continued in the district, a dam being built for water supply purposes. Some difficulty was ex-perienced, however, owing to the rising of the river and bursting of the dam. A bridge over the Wilge River was also built.

*Review Held.*—On June 28th a review of all troops in the district was held, those taking part being the 3rd Dragoon Guards, 1st Battalion Imperial Yeomanry, a Battery R.F.A., a section of mountain guns, 12th Company R.E., the Grenadier Guards, 1st and 2nd Battalions Black Watch, East Yorks, South Staffords and Manchester Regiments. This ended about a fortnight of sports and general festivities celebrating the coronation.

On July 16th the first batch of Reservists left for home, and the work of sending off the Reservists and men whose time was up was carried on thenceforward as fast as possible.

## APPENDIX I.

### ITINERARY OF MARCH—BLOEMFONTEIN TO PRETORIA.

| | | | | |
|---|---|---|---|---|
| 1st | May | Bloemfontein to Karee ... ... ... ... | 22 | miles |
| 3rd | ,, | Brandfort ... ... ... | 14 | ,, |
| 5th | ,, | Vet River ... ... ... | 22 | ,, |
| 6th | ,, | Smaldeel ... ... ... | 8 | ,, |
| 9th | ,, | Welgelegen ... ... ... | 14 | ,, |
| 10th | ,, | 2 miles N. of Rietspruit Station | 19 | ,, |
| 11th | ,, | Geneva siding ... ... ... | 15 | ,, |
| 12th | ,, | Kroonstadt ... ... ... | 14 | ,, |
| 22nd | ,, | Horning Spruit ... ... ... | 21 | ,, |
| 23rd | ,, | Rhenoster River ... ... | 16 | ,, |
| 24th | ,, | Vredefort Rd. Station ... ... | 15 | ,, |
| 25th | ,, | 2 miles N. of Grootvlei Station | 12½ | ,, |
| 26th | ,, | Taibosch Spruit ... ... | 17 | ,, |

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| | | | |
|---|---|---|---|
| 27th May | Vereeninging ... ... ... | 10½ | miles |
| 28th ,, | Klip River ... ... ... | 21 | ,, |
| 29th ,, | Germiston ... ... ... | 15 | ,, |
| 31st ,, | Johannesburg ... ... ... | 10 | ,, |
| 3rd June | Leeuwkop ... ... ... | 12 | ,, |
| 4th ,, | Zwart Kop ... ... ... | 14 | ,, |
| 5th ,, | Pretoria ... ... ... | 8 | ,, |

The 12th Company thus did 20 marches in 36 days, covering a total distance of exactly 300 miles.

## APPENDIX IIA.

### 12TH COMPANY, ROYAL ENGINEERS (24/9/1900 TO 19/9/1901).

### ADMISSIONS TO HOSPITAL—KOMATIE VALLEY.

Strength of Company on arrival at Komatie Poort (including Volunteer Section and Lieut. Elsner, R.A.M.C., attached) was 6 officers and 167 rank and file.

| | *N.C.O.'s and Men.* | | *Officers.* | |
|---|---|---|---|---|
| | *Actual Admissions.* | *First Time.* | *Actual Admissions.* | *First Time.* |
| October ... ... | 8 | 8 | – | – |
| November... ... | 23 | 23 | 1* | 1* |
| December ... | 39 | 38 | 2 | 2 |
| January ... ... | 23 | 13 | – | – |
| February ... | 14 | 6 | – | – |
| March ... ... | 15 | 8 | – | – |
| April ... ... | 28 | 14 | 3 | 3 |
| May ... ... | 55 | 32 | 4 | 3 |
| June ... ... | 25 | 8 | 2 | – |
| July ... ... | 28 | 3 | – | – |
| August ... ... | 14 | – | – | – |
| September ... | 5 | 1 | – | – |
| Totals ... | 277 | 154 | 12 | 9 |

* Lieut. Elsner, R.A.M.C. (attached).

Invalided :—34 men, 1 officer (2nd-Lieut. Reid, served only at Machadorp).

Died :—3 men.

Killed on railway :—1 man.

Since arrival at Harrismith, 30 rank and file have been invalided and 2 died out of those who were in Komatie Valley.

The above casualties refer to men who actually served in the Komatie Valley. Men who did not serve at Komatie Poort are not included, nor are any men of the First Volunteer Section under Lieut. Pollard.

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## APPENDIX IIB.

### 12TH COMPANY, ROYAL ENGINEERS.

RETURN OF DEATHS OF ANIMALS IN THE KOMATIE VALLEY FROM 24/9/1900 TO 19/9/1901.

| *Months.* | *Horses.* | *Mules.* | *Remarks.* | |
|---|---|---|---|---|
| September, 1900 ... | – | 1 | | |
| October, ,, ... | – | 7 | 1 destroyed | Included in totals. |
| November, ,, | 5 | 7 | 2 horses destroyed | |
| December, ,, ... | 3 | 16 | | |
| January, 1901 ... | 2 | 12 | 1 mule destroyed | |
| February ,, ... | 2 | 1 | 1 mule destroyed | |
| March, ,, ... | – | 2 | Destroyed | |
| April, ,, ... | – | 1 | Destroyed | |
| May, ,, ... | 2 | 1 | | |
| June, ,, ... | – | – | | |
| July, ,, ... | – | – | | |
| August, ,, ... | – | – | | |
| September, ,, ... | – | – | | |
| Totals ... | 14 | 48 | | |

Number marched into Komatie Poort :—
Horses, 19. Mules, 72.

## APPENDIX IIIA.

### HONOURS WON BY THE 12TH (FIELD) COMPANY, SOUTH AFRICA, 1899–1902.

*Officers.*

| | | |
|---|---|---|
| Major A. Graham-Thomson ... | Mentioned in Dispatches, | 4/9/01 |
| | Brevet Lieut.-Colonel, | 29/11/00 |
| Captain A. L. Schreiber* ... | Distinguished Service Order. | |
| | Mentioned in Dispatches, | 29/11/00 |
| Lieut. (afterwards Captain) A. J. Craven ... ... ... | Mentioned in Dispatches, | 8/4/02 |
| | Brevet-Major, | 26/6/02 |
| Lieut. R. H. MacDonald ... | Mentioned in Dispatches, | 4/9/01 |
| Lieut. J. J. H. Nation ... ... | Mentioned in Dispatches, | 4/9/01 |

*Other Ranks.*

| | | |
|---|---|---|
| C.S.M. C. Skinner ... ... | Distinguished Conduct Medal. | |
| | Mentioned in Dispatches, | 17/6/02 |
| 21691 Sergt. J. T. Hughes ... | Distinguished Conduct Medal. | |
| | Mentioned in Dispatches, | 17/6/02 |
| Sapper W. A. Gilham ... ... | Mentioned in Dispatches, | 17/6/02 |

* The Editor regrets that in the June issue of the *Journal* the name of Captain (now Brig.-General) Schreiber, D.S.O., was wrongly spelt.

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Those who did the march from Bloemfontein to Pretoria and Komatie Poort received the Queen's Medal with Clasps for "Cape Colony," "Orange Free State," "Johannesburg," "Diamond Hill" and "Belfast."

For the second period of the War, those who were with the Company received the King's Medal with Clasps, "1901," "1902."

## APPENDIX IIIB.

N.C.O.'S AND MEN OF THE 12TH (FIELD) COMPANY WHO WERE KILLED OR DIED, SOUTH AFRICA, 1899–1902.

| | | | |
|---|---|---|---|
| 22084 | Driver F. Wakefield | ... ... ... | 24/4/00 |
| 26398 | Sapper J. Burt | ... ... ... ... | 17/5/00 |
| 23721 | ,, R. Bromley | ... ... ... ... | 2/7/00 |
| 5801 | ,, J. Lawson | ... ... ... ... | 23/7/00 |
| 318 | Driver F. Pearce | ... ... ... ... | 1/10/00 |
| 27773 | Sapper J. Sawnders | ... ... ... | 14/4/01 |
| 8224 | ,, R. H. Wilson | ... ... ... | 29/11/01 |
| 20032 | Corporal W. Bartlett | ... ... ... ... | 14/12/01 |

## CHAPTER III.

From this time the Company remained in Harrismith until 1905, employed on general R.E. work on cantonments and barracks in the neighbourhood.

*Return Home.*—On March 19th, 1905, the Company left Harrismith for Home, being told that they were going to be sent to Aldershot.

On March 24th they embarked on the S.S. *Dunera* at Capetown, and arrived at Southampton on April 14th, disembarking the next day. Here there was great disappointment when the news was learned that, instead of Aldershot, Fermoy in Ireland was the Company's destination. This place was reached late in the evening of the 16th, the Company being sent to Moore Park.

*Moore Park, Fermoy.*—There were at this time no men in the Company who had not been abroad at least four years, many having been in South Africa for five and a half years.

They were quartered in the mansion which had been the old family seat of the Earls of Mountcashel, but had been purchased a short time before by the Government. The estate, some 900 acres in extent, was situated on the River Funshion and was well suited for training.

The Company was employed on the usual peace-time company, brigade, and divisional trainings, and under the Division Officer for works, road-making, etc. They also had no small work each year in preparing camps for training and manœuvres.

In 1908, on the formation of the six Divisions at home, the 12th

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and 38th Companies were allotted to the 6th Division, the headquarters of which were at Cork.

In December, 1908, a fire occurred at Moore Park and the mansion was almost entirely burnt down, leaving practically nothing but the walls standing.

There being no water laid on, the only method of dealing with the fire was a chain of buckets from the river, which, of course, proved quite inadequate.

The fire originated near the main staircase, in consequence of which many men had exceedingly hurried exits by means of knotted sheets from windows, etc., and were able to save practically nothing! They must have presented a somewhat motley appearance, an officer describing them as follows:—" It was quite the exception to see any of them properly dressed! I distinctly remember seeing one man wearing an officer's Wellington boot on one foot and a carpet slipper on the other! Many others were on a par!"

As they were now practically without accommodation, two huts were hurriedly removed from Clogheen and re-erected at Moore Park, and, having been reclothed and equipped, the Company once more reassumed its normal appearance.

In 1908 and 1909 the Company prepared camps at Aglish, in Co. Waterford, for divisional trainings which were carried out there.

In the spring of 1909 and 1910 the Company were assembled under canvas at Moore Park, having been somewhat dispersed under D.O.'s during the winter, owing to lack of accommodation.

It was at about this time that C.Q.M S. Fletcher transferred to the old balloon section which afterwards became the Royal Flying Corps. Fletcher subsequently obtained a commission, and, during the war of 1914–18, rose to the rank of Brigadier-General.

In 1910 the 17th and 59th Companies from the Curragh and 33rd (Fortress) and 38th from Cork came up to Fermoy for the Field Works course. Experiments in crossing wire entanglements were carried out on a large scale under the supervision of Major Godfrey-Faussett from the War Office.

In the autumn of 1910 Irish command manœuvres took place in the Wexford area, the 5th Division fighting against the 6th.

In the spring of 1911 the 12th and 38th Companies, after doing pontooning at Baltray on the Boyne (a tidal river) near Drogheda, prepared the camp for, and took part in, the large review of troops in Dublin on the occasion of the visit of H.M. the King, after which they returned again to Moore Park, and carried out similar annual trainings, etc., until 1914 arrived, bringing with it something in the way of variety!

(*To be continued.*)

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## *PROFESSIONAL NOTES.*

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## EXPLANATORY NOTES ON THE ACTIVATED SLUDGE PROCESS.

*The Purification of Sewage and Trades Waste* by an entirely aerobic process, free from objectionable odours, has always been the ideal method which sanitary engineers and chemists have had before them, and it has at last been rendered possible by the Activated Sludge Process.

*The Aeration of Sewage*, by blowing air through it, was often attempted, but it was found to require an altogether excessive time and volume of air, and the result left an effluent which needed to be further treated on filters.

The Activated Sludge Process consists not merely of aeration or agitation of the sewage, but the combination of both, with the retention in the tank of the sludge, indigenous to the sewage, but activated by the process of aeration.

Hitherto, with any sedimentation or septic tank process, retention in the tank induced anaerobic conditions, a bad smelling effluent, and a worse sludge of so little fertilizing value, that the problem of sludge disposal often became more serious than that of purifying the liquid contents of the tank.

Activated sludge is built up by aeration, gradual at first, the more or less purified liquid being drawn off and its place taken by more sewage, until about 25 per cent. of the tank contents consists of activated sludge. This proportion is then maintained and the surplus sludge can be drawn off and will be found to be innocuous, to settle rapidly, and contain valuable fertilizing properties, so that the Activated Sludge Process not only yields a pure effluent, but without further cost it also completely changes the character of the sludge and converts it into a valuable asset.

*The Process of Purification.*—The crude sewage is first rough screened and its detritus settled out. The light organic matter is retained, aerated and agitated until it is in a fine state of subdivision, and will pass through the fine screen. It is then mixed with activated sludge and aerated for the necessary period, passing through the circuit of the aeration tank until it is finally discharged into the settlement tank fitted with a special inlet. Here the sludge rapidly settles and a proportion of it is withdrawn by means of

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air lifts for further use whilst the surplus passes to sludge beds or tanks for de-watering and drying. Before, however, the activated sludge is returned to the aeration tank it is usually re-aerated, *i.e.*, air is blown through it in its concentrated state, as it flows back from the settlement tank to the sewage inlet.

*Trades Wastes* and the periods of aeration they require vary enormously, but sewage containing trades wastes, if alkaline, can be purified without any difficulty.

*Existing Tanks Can be Used.*—Tanks which have been sufficient for ordinary sedimentation or septic liquefaction will be ample for the complete treatment of the sewage by the Activated Sludge Process, when properly equipped.

*No Filters or Other Bacteria Beds are Required* as a stable effluent of almost any degree of chemical and biological purity can be obtained by a few hours' treatment in the aeration tank, followed by about one hour's settlement in another tank. The whole process is one continuous operation requiring very little labour and, whereas bacteria beds required from 4 ft. to 10 ft. of fall, 4 in. to 10 in. is now sufficient, or the effluent can be raised and discharged at a higher level as part of the process.

REPORT ON WORKING OF SEWAGE DISPOSAL PLANT (ACTIVATED SLUDGE SYSTEM) AT CHILWELL FOR THE PERIOD 1/2/23 TO 1/2/24.

*Installation.*—The plant was installed by Activated Sludge, Ltd., and commenced working on 25th January, 1923. The work was done in a thoroughly efficient manner, and the firm gave all assistance and advice necessary until the process of activation was complete, and the system in working order. Their representative has also paid periodical visits since, and has expressed himself satisfied with the working. An abridged description of the plant appears in Appendix A.

*Initial Outlay.*—The capital cost of the installation was as follows:—

| | | |
|---|---|---|
| (*a*) Construction of tanks ... | ... £1,261 | approximate |
| (*b*) Supply and erection of plant | ... £3,077 | figures |
| | £4,338 | |

The cost of (*a*) was considerably increased owing to unforeseen difficulties in keeping the excavations free from water. The firm's engineer afterwards stated that it would be possible to design a shallower pattern of tank for use in ground known to be heavily water-logged, and thus reduce excavation.

*Chemical and Other Tests.*—Samples of the crude sewage, the activated sludge, and the effluent were frequently analysed at the commencement, the latest of these tests being made on 6th June,

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1923, the results of which are shown on an annexure to this report.* Mr. Gaul, of Manchester University, who carried out this test, remarked that " the purification effected is very satisfactory both from a chemical and also from a bacteriological point of view." Since the above date the effluent has remained clear, and it has not appeared necessary to obtain further analysis.

Routine tests are made as follows, and records kept :—

(1) daily for percentage of sludge,
(2) daily for nitrification.

*Inspections and Visits.*—During the year the installation has been inspected by :—

The D.A.D.H., Northern Command, on 4th May, 1923, who made certain criticisms and suggestions on minor points, which have been attended to.

The District Inspector, Ministry of Agriculture and Fisheries, Grimsby, on 13th April, 1923, who stated : " I was agreeably surprised at the nature of the effluent, and if all the effluents reaching the rivers in this country were as good, our pollution troubles would soon end."

Deputations from several public bodies, including the Medical Officer to the Notts County Council, have also visited the plant.

*Machinery.*—The three compressors (Reavell's, driven by motors of the English Electric Co.) have proved entirely satisfactory, and repairs during the period have been negligible.

No renewals of diffusers have been necessary during the period.

The ejectors have worked satisfactorily, and only on one occasion, at a time of exceptional storms, were unable to cope with the flow. They have been fitted with counters, thus enabling an exact record of the quantity of sewage dealt with to be kept.

An alternative supply of compressed air has been arranged from the Power House, by making use of a disused steam main, thus enabling the compressor house to be closed during non-working hours, and minimizing the risk of failure.

*Maintenance Staff.*—The supervising electrical and mechanical engineer is responsible to the Division Officer, R.E., for the running of the plant. The foreman of the heating and ventilating department is the immediate supervisor, and it is to him that the present satisfactory state of the installation is largely due. Under him there work one full-time attendant at 48 hours per week, and a second attendant at an average of half-time. The arrangement by which compressed air is supplied from the Power House during non-working hours, and at week-ends, makes it possible to work the plant with this staff. If, however, the local compressors had

* Appendix " B."

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to be worked continuously, shift-working would be unavoidable, and three men would be essential. The firm stated, in reply to enquiries on this point, "We think it advisable that you should have a man at the compressor house continuously. If, at the end of six months, you find two men sufficient, you can then reduce."

From the above it will be evident that, if a plant of this nature were contemplated at a station where no alternative supply of compressed air exists, it would be necessary to estimate for a sufficient staff for continuous, or practically continuous, attendance. In such a case the best solution would appear to be to employ a "whole-time" attendant, who would be provided with a quarter close to the compressor-plant, and a day-worker in addition.

*Disposal of Sludge.*—When the percentage of sludge in the system reaches from 20 to 25 per cent., the sludge from the settling tank is drawn off by means of air-lift pumps into shallow lagoons to dry. At this stage it is in the form of a thick black liquid. This operation takes place, on the average, once a week, and the quantity drawn off each time is in the neighbourhood of 6,000 gallons. The lagoons are dug about 15 in. deep, and have an area of, roughly, 260 sq. ft. each. It has been necessary to dig nine only up to date, thus occupying only a very small proportion of the ground available for the purpose, and leaving ample for the future; as a matter of fact, the earliest of these lagoons still soaks the water away almost as well as it did at the beginning.

The sludge is run into the lagoons to a depth of 9 in., and after remaining for 24 hours, the water has soaked away, leaving a black paste. This paste dries up to a solid crust about an inch thick, the drying period varying with atmospheric conditions, but seldom being more than a week. The dried sludge is then taken off with a shovel, and the lagoon is ready again for its turn.

Up to date the dried sludge has been taken away by neighbouring farmers as an experiment. We shall perhaps learn their opinion as to its manurial value after this season's cropping. The amount taken away during the twelve months may be roughly estimated at 170 tons, but no exact record has been kept.

*Cost of Treatment.*—An analysis of the costs for twelve months' working from 1st February, 1923, to 1st February, 1924, is given in an annexure to this report.* It should be noted that the figures given therein include power for lifting the sewage into the tanks by means of ejectors, from a depth of 15 ft. But for this, the cost per 1,000 gallons would be appreciably less than 10·89d., though it would be difficult to dissect the figures with any approach to accuracy.

* Appendix "C."

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*Effects of Oil.*—The presence of oil, especially if of a tarry nature, adversely affects activation, and the greatest care should be taken that no excess of heavy oil is used in urinals. The strictest supervision in this matter is necessary if the smooth running of the process is to be maintained.

*Conclusions.*—The results of a year's working are considered to show that the process is a very efficient one. It is especially suitable for a station where the space necessary for land treatment is restricted. The whole process is noticeably free from smell and flies, and this applies even to the dried sludge when stacked before removal. No definite defects have come to light in connection with the plant, and no particular improvements have suggested themselves.

## APPENDIX A.

### Description of Plant.

| | |
|---|---|
| Population on which capacity is based ... ... | 2,000 |
| Estimated dry-weather flow per day ... ... | 50,000 gallons |
| *Maximum* capacity per day ... ... ... | 500,000 gallons |
| Average volume treated per day (to date) ... | 103,490 gallons |

*Dimensions of Tank, etc.*

1. Disintegration tank—12′ diam., 7′ 9″ deep.
2. Three aeration channels, 54′ long, 4′ 6″ wide, 7′ 9″ deep.
3. Settlement tank, 15′ × 15′ × 19′ 3″ deep, with hopper bottom, fitted with Clifford inlet.
4. Sludge return channel, 54′ long, 2′ wide, 7′ 9″ deep.

The walls and floors are of Portland cement concrete, 1 : 6. The floors are rendered with P.C. mortar, 1 : 3, well trowelled. The concrete in the walls was well trowelled against casings; after removing the casings it was decided that rendering was unnecessary, the surface being free from air-holes. Thickness of floor, 12″; external walls and walls under hydrostatic pressure, 12″ thick; longitudinal partition walls, also the transverse baffle walls, are 6″ thick.

### Specification for Air-Compressing Plant.

1. Rotary type compressor, direct coupled to electric motor, capable of delivering 150 cub. ft. of free air per minute against a pressure of 10 lb. per sq. in.
2. As No. 1, but motor of variable speed type having a range down to a speed of one-third.
3. As No. 1, but against a pressure of 4 lb. per square inch.
4. Air receiver, 75 cub. ft. capacity, and tested to 25 lb. per square inch.

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## APPENDIX B (1).

### ANALYSIS OF CRUDE SEWAGE.

| | |
|---|---|
| Nature of sample ... ... | Crude sewage |
| Date received ... ... | May 31st, 1923 |
| Date of report ... ... | June 6th, 1923 |
| Laboratory number ... | No. 7 Chilwell |

| | |
|---|---|
| Description of sample ... | Pale yellow liquid, containing a moderate amount of solids in suspension : slight smell. |

| | |
|---|---|
| Nitrogen as : | |
| Free and saline ammonia ... ... | 1·2 |
| Albuminoid ammonia ... ... | 1·5 |
| Nitrites ... ... ... ... | *Nil* |
| Nitrates ... ... ... ... | *Nil* |
| Nitrites and nitrates | |
| Oxygen absorbed in : | |
| 4 hours | |
| 3 minutes ... ... ... | 9·2 |
| Suspended solids | |
| Percentage purification, calculated on the 4-hour figure | |

## APPENDIX B (2).

### ANALYSIS OF ACTIVATED SLUDGE.

| | |
|---|---|
| Nature of sample ... ... | Activated sludge |
| Date received ... ... | May 31st, 1923 |
| Date of report ... ... | June 6th, 1923 |
| Laboratory number ... | No. 8 Chilwell |

| | |
|---|---|
| Description of sample ... ... | Winchester quart of liquid, containing sludge |

The sample is very similar to those previously sent. A microscopical examination reveals the presence of only a few protoxos.

## APPENDIX B (3).

### ANALYSIS OF FINAL EFFLUENT.

| | |
|---|---|
| Nature of sample ... | Final effluent |
| Date received ... ... | May 31st, 1923 |
| Date of report ... ... | June 6th, 1923 |
| Laboratory number ... | No. 9 Chilwell |

| | |
|---|---|
| Description of sample ... | Clear, colourless liquid, containing a trace of sludge in suspension. No smell. |

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| | *Parts per* 100·00 |
|---|---|
| Nitrogen as: | |
| Free and Saline Ammonia ... | ·6 |
| Albuminoid Ammonia ... ... | ·08 |
| Nitrites ... ... ... ... | Faint |
| Nitrates ... ... ... ... | |
| Nitrites and Nitrates ... ... | ·30 |
| Oxygen absorbed in: | |
| 4 hours ... ... ... | ·5 |
| 3 minutes | |
| Suspended solids | |
| Percentage purification calculated on the 4-hour figure ... ... ... ... | 94·5 |

## APPENDIX B (4).

### Analysis of New Sewage and Final Effluent.

| | |
|---|---|
| Nature of sample ... | New sewage and final effluent |
| Date received ... ... | May 31st, 1923 |
| Date of report ... ... | June 6th, 1923 |
| Laboratory number ... | Nos. 7 and 9 Chilwell |
| Description of samples ... | See chemical analysis sheets |

### Bacteriological Counts.

Number of bacteria growing on gelatine peptone broth, when incubated for three days at 21° C.

| | |
|---|---|
| Raw sewage ... ... | 2,700,000 |
| Effluent ... ... | 13,700 |
| Percentage reduction ... | 99·5 |

## APPENDIX C.

### Analysis of Costs.

### Sewage Disposal Works—Chilwell.

*Period:* February 1st, 1923, to January 31st, 1924.

| | £ | s. | d. |
|---|---|---|---|
| *Direct Operating Charges* | | | |
| Labour, civilian ... ... ... ... ... ... | 186 | 6 | 11 |
| Power, electric ... ... ... ... ... ... | 598 | 7 | 3 |
| ,, steam ... ... ... ... ... ... | 451 | 6 | 9 |
| Stores, water ... ... ... ... ... ... | 3 | 5 | 4 |
| ,, oil, grease, etc. ... ... ... ... ... | 14 | 10 | 11 |
| *General Standing Charges.* | | | |
| Machinery and Plant— | | | |
| Depreciation ... ... ... ... ... | 204 | 0 | 0 |
| Repairs and renewals ... ... ... ... | 16 | 11 | 10 |
| Storage tanks, etc.—Depreciation ... ... ... | 62 | 5 | 11 |

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| | £ | s | d. |
|---|---|---|---|
| *General Standing Charges*—continued. | | | |
| Quartering—Rental value, W.D. property ... ... | 59 | 0 | 7 |
| Repairs ... ... ... ... ... ... | 39 | 9 | 5 |
| Rates ... ... ... ... ... ... | 2 | 5 | 0 |
| Barrack Services—Barrack furniture, utensils, etc. ... | 1 | 13 | 4 |
| Engineer's salary (proportion) ... ... ... | 35 | 4 | 6 |
| Caretaking and custody—Police ... ... ... | 7 | 15 | 8 |
| *Administrative Charges.* | | | |
| Military—Officers ... ... ... ... ... | 29 | 6 | 4 |
| Stationery, Army Forms and Books ... ... ... | 3 | 3 | 7 |
| Total ... | £1,714 | 13 | 4 |

| | |
|---|---|
| Gallons treated (12 months) ... ... ... | 37,773,870 |
| Cost per 1,000 gallons ... ... ... ... | 10·89d. |

*Note.*—It is to be observed that the Chilwell Army Ordnance Depôt is largely a factory, but partly residential. The residential population is 450 and the factory population, who are there 8 hours per diem, about 1,000–1,200. There is a laundry operating in the factory which consumes a large quantity of water.

As regards the plant being worked to only about 1/5th of its capacity, it should be explained that rainfall is only partly separated from the sewage and that, as much of this rainfall is foul, allowance in the capacity of the works had to be made to meet heavy rainfall together with prospective additional sewage.

These factors render it somewhat uncertain as to how the running expenses would compare with those of an installation in a purely barrack area, but the comparison would probably be much in favour of the latter as laundry water and factory waste water constitute a more difficult sewage to treat than that of a purely domestic nature.

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## SHORT NOTE ON THE PUNJAB HYDRO-ELECTRIC SCHEME.

1.—Shortly after the Armistice the attention of the Punjab Government was drawn to the possibility of generating power in bulk on a sufficiently large scale to supply the whole of the Eastern Punjab, from a large bend on the River Sutlej near Bhakra, a site already selected for the construction of a large irrigation dam in connection with the "Bhakra Irrigation Scheme," a project for which had just been completed.

2.—In October, 1919, the services of Bt. Lieut.-Colonel B. C. Battye, D.S.O., R.E., who designed and constructed the Simla Hydro-Electric Scheme prior to the outbreak of war, were obtained on deputation for this purpose.

3.—The site eventually selected was surveyed during the following cold weather and an elaborate census of the horse-power already installed in the province prepared

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4.—This work included an investigation of two alternative sites for a small subsidiary power scheme for some 6,000 kw. to supply power urgently needed in connection with the Simla Water Works, the electrification of the Kalka-Simla Railway and the construction of the abovementioned irrigation and power projects on the Sutlej.

5.—A low-head site on the Sutlej was eventually selected at Nangal and a preliminary project report prepared in detail.

6.—The following year a complete report on the whole scheme was prepared; this was finally submitted to Government in June, 1921.

7.—The four volumes dealing with the Main Sutlej River Project were eventually published and copies were presented to the Institutes of Civil and Electrical Engineers in London, and to the American Societies' Library in New York.*

8.—This work was carried out by the following officers under the superintendence of Lieut.-Colonel Battye:—

Major R. N. Aylward, D.S.O., M.C. (late R.E.), who was responsible for the subsidiary projects and estimates for temporary equipment.

Major G. H. Hunt, M.C. (late R.E.), who was responsible for the survey work and civil engineering.

Lieut. A. Guthrie, R.E., for the electrical work; and Mr. B. K. Sibou, late of the Thomason College, Roorkee, who prepared the census and revenue estimates.

9.—The above report recommended the formation of a Punjab Hydro-Electric Commission, in order to co-ordinate the various interests of the province connected with development of electrical power in bulk. An Advisory Board was formed in June, 1922, and has been mainly instrumental in getting the Uhl River project surveyed and worked out.

10.—In April, 1922, the Punjab Government decided to proceed with the Nangal Subsidiary project; a Hydro-Electric Circle was formed, with Lieut.-Colonel Battye as Superintending Engineer, to construct the Nangal Scheme, with the assistance of the same staff as before, except Major Aylward, whose services had in the meantime been re-engaged to carry out a Hydro-Electric Survey of the Punjab as a whole. Major Aylward formed a Hydro-Electric Survey Division, which was placed under the above Circle, and has in the last two years completed a survey of the water-power resources of the Punjab. He is now writing a report which it is hoped shortly to submit to Government. This survey includes an area extending to 50 miles outside the political boundaries of the Punjab proper, and has revealed the existence of over one million horse-power capable of commercial development as soon as a market exists for it.

* See Appreciation, *R.E. Journal*, June, 1924, p. 267.

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11.—During the preparation of the final report on the Nangal project, two of the most important Government Departments, who had promised to use power, fell out of the scheme, rendering it unproductive. During the discussion which followed Major Aylward discovered the site of the Uhl River Hydro-Electric Scheme in Mandi State. After considerable further discussion it was decided to drop the Nangal Subsidiary Scheme altogether and concentrate on the preparation of a detailed project for the Uhl River Hydro-Electric Scheme, which would replace both the Sutlej and the Nangal Schemes as a primary development, the Sutlej Scheme being postponed till after the Uhl River one has been loaded up.

12.—It should be explained at this stage that the Sutlej Project dealt with some 3,300 cusecs, through a fall of 320 ft. necessitating a two-mile tunnel, expensive headworks (the latter complicated by the existence of the proposed Bhakra dam), and two miles of 10 ft. pipe-line, the latter making speed regulation rather difficult and thus militating against the scheme as a primary development, but not as a second, if run in parallel with existing stations.

13.—Power was to be transmitted throughout the eastern half of the Punjab, from Delhi in the south to Lahore and Lyallpur in the north, at a pressure of 132 kilo-volts.

14.—The scheme was laid out for the development of 80,000 kw. at first in one station, but capable of expansion in two more similar stations after the completion of the Bhakra dam, to a total of 240,000 kw. The project was estimated to cost some 735 lacs, to start with, extending to a total of 1,100 lacs, eventually, for the full preliminary development of 80,000 kw.

15.—The Nangal Project involved the handling of 2,000 cusecs, two miles of canal for the same and a 32 ft. drop.

16.—The Uhl River Project, situated much further up in the Himalayas, contemplates a fall of 3,000 ft. in two stages of 1,800 ft. and 1,200 ft. respectively, $2\frac{1}{2}$ miles of tunnel and the handling of only 600 cusecs, eventually. The latter scheme, however, necessitates longer transmission lines in the mountains and the construction of 84 miles of metre-gauge railway to serve the site of the power station, and incidentally the Kangra valley and district, which is urgently in need of railway communications.

17.—The Uhl River project was surveyed during the cold weather of 1922–23, and a detailed project worked out last summer.

18.—This project has since been submitted for scrutiny to three committees specially formed for the purpose, one to deal with the railway proposals, a second with the civil and hydraulic engineering features and a third with financial and revenue aspects of the scheme.

19.—The report has now been completed and published in four parts. The above committees have completed their scrutiny and their reports are embodied in Part I.

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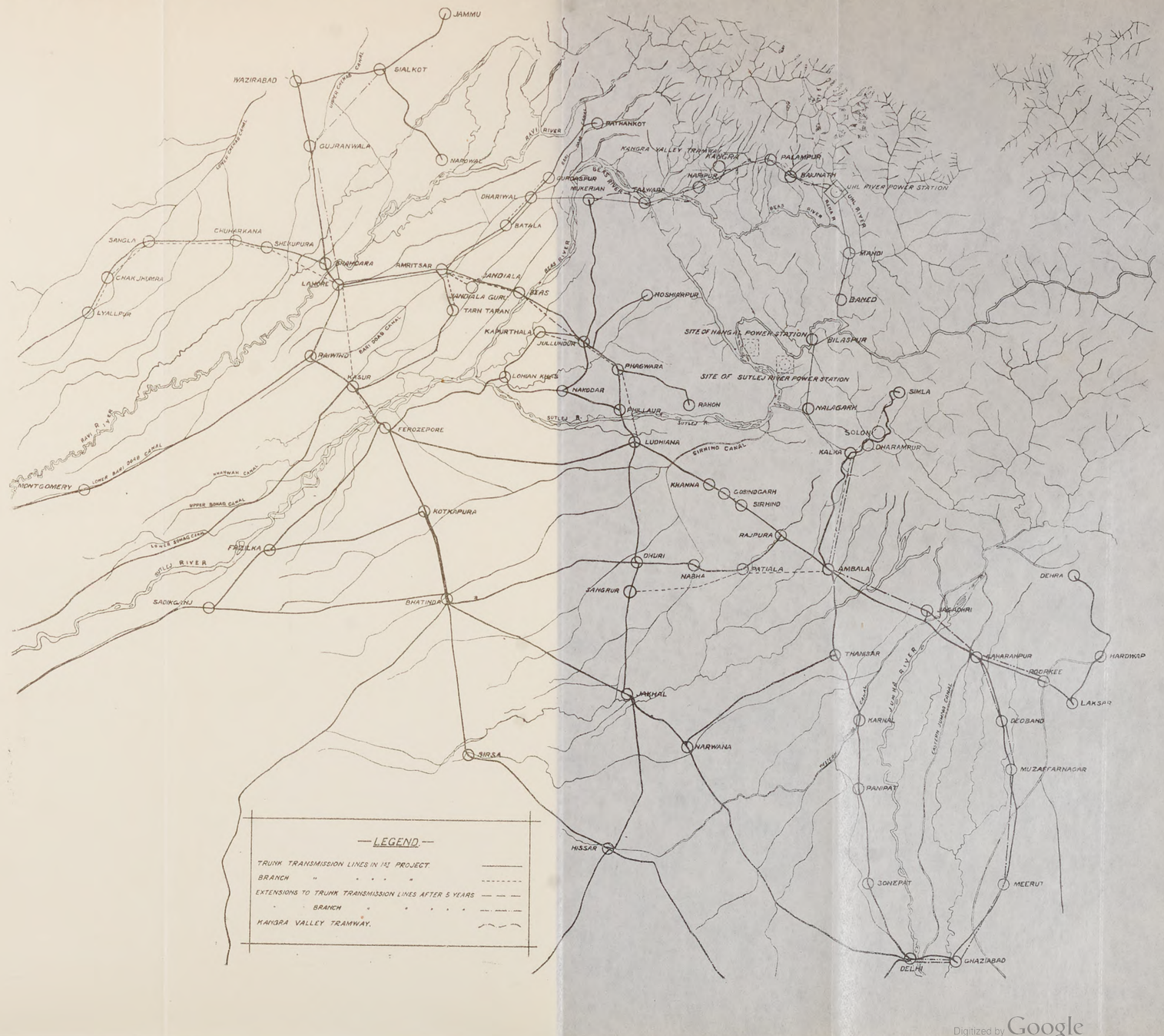
# THE EASTERN PUNJAB AND U.P., SHOWING THE UHL RIVER HYDRO-ELECTRIC SCHEME.

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20.—The report is now about to be examined by Messrs. Merz and McLellan in London, and if their report is as satisfactory as those of the local scrutiny committees, it is probable that the project will mature and work start this autumn.

21.—The scheme involves the supply, to start with, of 26,000 kw extending by stages to 111,000 kw., supplying the whole area in the Eastern Punjab, from Delhi to Lahore, Lyallpur and Sialkot.

22.—A map showing the scope of the scheme is attached.

23.—Promises have been received for sufficient power to pay working expenses and interest charges from the second year of operation, while the normal growth of industry will enable it to meet the depreciation and sinking fund charges as well as a net return varying from 6 to 10 per cent. after the fifth year of operation.

24.—The scheme, inclusive of the railway, is estimated to cost approximately 563 lacs, to start with, extending by degrees to a maximum of 1,145 lacs, when the whole capacity of the site (111,600 kw.) is utilized. The report on the Uhl River Project was carried out by the same staff as that used for the Nangal Scheme, except that the services of Lieut. A. Guthrie, R.E., who was ordered home to Cambridge just before the surveys commenced, were replaced by those of Captain H. A. Kenyon, M.C., R.E., who has been in charge of the transmission lines and electrical side.

25.—If the project matures there will be opportunities for the employment of several engineer officers during the period of construction, which is expected to extend over $3\frac{1}{2}$ years to start with, and an additional three years after that, on extensions consisting of a dam and the development of the lower head.

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## ELECTRIFICATION OF MILITARY STATIONS IN INDIA.

VERY considerable progress has been made in recent years in carrying out the Government of India's policy of electrification.

This provides for the electrification of the lines of British troops and of all hospitals. The complete scheme, of which approximately 3/5ths is completed or in hand, is estimated to cost approximately $2\frac{1}{4}$ crores of rupees (£1,500,000).

Electrification of stations in the plains provides not only for the electric lighting of barracks and other buildings, and for street lighting, which is often undertaken on behalf of Cantonment Committees, but for the provision of electric fans and electrically operated trains of punkahs, where these latter can be conveniently and economically installed in place of fans.

At certain frontier stations perimeter lighting has also been provided.

The demand for electric power for other than domestic purposes is

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not at present great, but is growing. Motor-driven pumps, motor-driven compressors in ice factories and electric-drive in workshops have been installed in some cases.

The total number of stations electrified is 36. In addition, the hospitals only, or certain individual groups of buildings, are electrified at 16 other stations.

At those stations where it can be arranged to obtain a satisfactory bulk supply of energy from an outside source, *e.g.*, a municipality, an electric supply company or the P.W.D., the Military Engineering Services are only required to provide for transforming and conversion, where necessary, for distribution and, of course, for the internal wiring. In a few instances a distributed supply has been provided by the outside agency.

There are, however, 39 power stations operated by the M.E. Services, 29 of which are for station supplies and the remainder for hospitals or for other minor individual purposes.

The amount of plant installed in a station power house which, of course, depends on the size of the station, varies from about 100 kw. to 450 kw., excluding the smaller electrified frontier stations. At the largest station the connected load is over 600 kw. and the consumption, in 1922–23, was over 800,000 units.

A very great variety of plant has been installed. Standardization is, of course, out of the question, though it has been found possible to introduce it to a limited extent. A similarity of practice is at all events aimed at.

At most stations the distribution is D.C., 440 volt, 3 wire. Some of the smaller stations are 220 volt, 2 wire, and at a few stations, where a H.T. supply is taken from a Company, an A.C. supply is installed, whilst in other cases the Company H.T. supply is converted to D.C. for distribution.

## Military Ice Factories.

There are ten ice factories operated by the Military Engineer Services. These, which have a total capacity of 24 tons, are all at frontier stations. The largest individual factory has a capacity of seven tons. One-ton plants are mostly installed. There are, however, two 4-ton plants.

## Military Water Supplies.

The majority of cantonments have their own independent water supplies, but with water, as with electric power, advantage is taken of municipal or other outside sources of supply, where these are available and satisfactory, to so obtain the military supply or to have a joint supply.

The independent military supplies and the military or partially

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military worked joint supplies are very varied in character, from rivers, from dams, from wells, from boreholes, some pure at source and some very impure. A great variety of engineering work is therefore involved, and the pumping plant is even more varied and less standardized than the electric power station plant.

The military pumping stations total 77.

R. OAKES.

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## ELECTRIFICATION OF HIS MAJESTY'S MINT, BOMBAY.

TILL recently the Mint was driven by steam-power plant, most of which was old, unreliable, and uneconomical. It was therefore decided to replace it by electric motors. A 3-phase electric supply at 5000 volts was available from the Bombay Supply Co. A sub-station with static transformers to step down to 400 volts was installed, and current at this pressure is delivered to the A.C. motors which have been installed throughout.

Full specifications for all the plant were prepared by the Mint, and were issued for tender to selected firms who had branches in Bombay. The tender of Messrs. Metropolitan Vickers was finally accepted. The plant was delivered to the Mint, and the firm supplied an erecting engineer to superintend generally: the actual erection of the whole plant was carried out by the Mint, including the foundations, building work, lining up motors and shafts, etc.; the Mint also undertook all steel work for brackets, ladders, railings, etc.

The machines in the Mint are of many kinds, but the determination of the sizes of motors required was facilitated by the fact that similar plant at the Calcutta Mint was already driven by electric motors. The arrangements for drive adopted are as follows: The general workshop, die department, cutting machines, small coining presses, and other plant not taking much power are driven by squirrel-cage induction motors of sizes up to 15 h.p. In order to avoid the heavy expense of re-arranging the extensive slow-speed overhead shafting and pulleys, back-geared motors with fabric pinions were chiefly used for this work, and have proved quite satisfactory. Motors over 3 h.p. have oil-immersed star-delta starters with overload and no-volt trips. The air pumps working the large coining presses are each driven by a 60-h.p. plain slip-ring induction motor. The rolls are driven by similar motors, the adjusting rolls having motors of 20 h.p., the medium rolls motors of 40 h.p., and the breaking-down rolls motors of 150 h.p. All slip-ring motors have oil switches with overload and no-volt trips for the stators, and liquid starters for the rotors. The 40-h.p. and 150-h.p. motors have fly-wheels, and ohmic resistances are permanently included in their rotor circuits to permit of fly-wheel effect being utilized.

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Silent chains are used to drive some of the smaller rolls. Worm-gearing is employed for the larger rolls, *e.g.*, each 150-h.p. motor is mounted on one bedplate with its fly-wheel and worm-gear which runs in oil and reduces the speed from 580 r.p.m. to about 28 r.p.m in a single reduction: this gear stands about 7 ft. high; it makes a compact and efficient job.

A main switchboard mounted in a central position receives current from the sub-station through three 3-core 0·4 square inch cables, and controls the feeders to departments. The feeders proceed to distribution boxes to which the motors are connected.

The power factor of the plant is low on light loads: extra charges for energy are made for a low P.F., while a rebate is given if the P.F. is over 80 per cent. Two 3-phase static condensers made by B.I. and Helsby Cables have therefore been installed to improve the P.F., having capacities of 57 and 116 K.V.A. respectively; they can be connected individually by oil switches to the bus bars of the main switchboard, so that 57, 114 or 171 K.V.A. can be used. They have been most successful, and it is usually possible to keep the P.F. near to unity. It is expected that the savings will cover the cost of the condensers in quite a short time.

The plant is working very satisfactorily. The horse-power installed is about 740. One engineer looks after the whole electrical plant, and has two men to oil and clean, etc., whereas the steam plant required about 30 men. Detailed figures of relative running costs are not yet available, but the savings are considerable.

R. E. STACE, *Major, R.E.*
*Mint Master.*

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## THE EMPLOYMENT OF ROYAL ENGINEER OFFICERS ON INDIAN STATE RAILWAYS.

AN officer writing at the end of the year 1923 says that, with the exception of the Khyber Railway (of which a separate account was given in the June number of the *R.E. Journal*), there was not much new railway construction in hand in India.

Many officers of the Corps, however, were engaged on open-line work. Colonel Sir Danvers Waghorn was a member of the Railway Board, Colonel H. E. C. Cowie was temporarily attached to the Board as Chief Engineer and Major F. H. Budden was in the statistical branch on special duty, inaugurating a vast new system of improved figures. Six Lieutenant-Colonels and three Majors were Government Inspectors.

Colonel H. A. Cameron was agent of the Eastern Bengal Railway, having recently returned from leave, during which Colonel G. R. Hearn had been acting for him. Lieut.-Colonel C. Walton was senior deputy agent of the North Western Railway and Major W. F.

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Mathews was acting Chief Engineer of the Oude and Rohilkund. Among retired officers, Major-General Sir Henry Freeland was agent of the Bombay, Baroda and Central India Railway, Brig.-General Sir Charles Magniac of the Madras and Southern Mahratta, and Lieut.-Colonel W. R. Izat of the Bengal and North Western.

Major W. Macrae and Captain H. de L. Panet had just completed the Bombay-Karachi Connection Survey from Ahmedabad to Radhanpur; gradients and sandhills defeated them in their attempts to improve on the previous alignment along the north of the Rawn of Cutch, between Radhanpur and Badin.

Major R. N. Burn, Deputy Chief Construction, N.W. Railway, was relaying the Kasur Lodhran branch (picked up to supply Mesopotamia and other places during the war) with an 80-mile realignment between Pakpattan and Mailsi to suit the new Sutlej Canal system. His duties, besides, embraced the Khyber construction, various surveys and conversions, examination of schemes to improve the capacity of sections, and so on.

Major M. T. Porter had just become Deputy Chief Engineer, Southern Section, N.W. Railway. A deputy's charge on the N.W. Railway is approximately four districts of 500 miles each; extensions, remodelling of yards, improvements of water supply, 125 miles of track renewals come his way and, if lucky, he may have a lay-out of large shops, or a gradient improvement, or a large bridge that is overstressed, or the control of a meandering river thrown in to keep him busy between budgets and retrenchment programmes.

Major H. L. Woodhouse was looking after the permanent-way of the N.W. Railway and had a creosoting plant at Dhilwan, turning out 300,000 sleepers annually. The stores balances of Indian railways have of late become the butt of the managements, so that a permanent-way officer's energies are devoted to the elimination of obsolescent types, in addition to the economics of supply and distribution of materials. Concrete sleepers also are being tried.

The traffic departments claimed Lieut.-Colonel C. S. M. C. Watson and Captain G. Walton.

There were no R.E. officers in the locomotive or carriage and wagon departments, it being the precedent for them to undergo a locomotive course, but for reasons unknown, not to remain longer in those departments.

Captain H. H. E. Gosset was personal assistant to the Chief Engineer, N.W. Railway, and was looking after the large engineering staff of officers, permanent-way inspectors, inspectors of works, clerks, etc., down to time-keepers and tracers.

The responsibilities of executive work in India have increased considerably. The assistant engineer grades are being filled more and more by Indians who, to say the least of it, require more encouragement and supervision than the older generation

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Captain R. E. Gordon had recently been attached to the signal department and was employed on the new lay-outs of yards that required remodelling.

The War is responsible for a hiatus in the number of R.E. officers taking up railway work, but it is good to observe a few junior officers coming on, like Waghorn, Panet, Dawes and Biddulph, and it is hoped that others may shortly be appointed.

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The 25th Railway Company, Royal Bombay S. and M., were employed during the past year in construction and rapid plate-laying through jungle country.

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## NOTES ON THE GLENO DAM FAILURE.

ON 1st December, 1923, the reinforced concrete power dam at Gleno, in Northern Italy, failed, causing great destruction to life and property in the valley below. A description of the dam and the result of the investigation into the causes of failure appeared in the *Engineering News Records* of the 31st January, 1924, and of 20th March, 1924, but, as many lessons can be learnt from failures of structures, a *résumé* of the articles is given below for the benefit of those who have not had the opportunity of reading the description themselves.

The Gleno dam, built after the war and only recently completed, was a reinforced concrete structure of multiple arch type resting on a gravity base of stone masonry.

The dam was about 800 feet long, and on most of its length ranged from 80 to 100 feet high, but in the narrow central gorge the height was about 160 feet. The gravity base filled the gorge and gave a horizontal base to the cellular or multiple-arch concrete superstructure which stretched across the valley. *Fig.* 1 shows the completed dam looking upstream.

The multiple-arch superstructure consisted of semi-cylindrical arches, 26 ft. 3 in. in span between centres of buttresses and inclined 53 degrees to the horizontal.

The type of construction can be understood from *Fig.* 2, which shows the upstream face of the dam after the breach had occurred.

From an analysis of the design of Dr. A. Stucky, of Basel, made by drawing pressure lines and computing stresses on horizontal sections, no abnormal conditions were found. Taking inclined sections, slight tensile stresses were found to exist in the buttresses near their upstream edges, but these could not be considered serious. The maximum horizontal shear was below 60 lb. per square inch and the maximum diagonal shear about 70 lb. per square inch. Failure therefore does not appear to have been due to faulty design.

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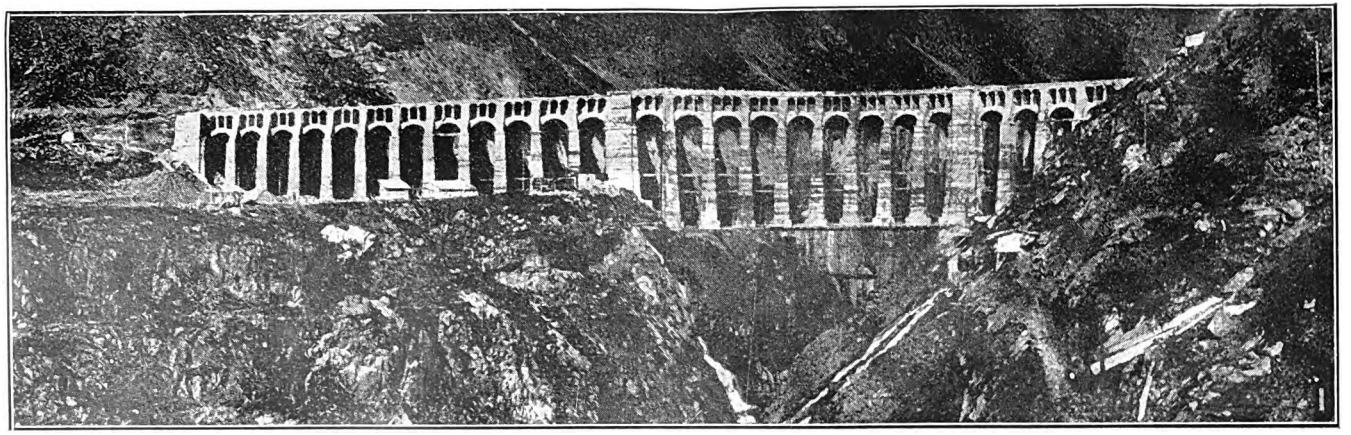

Fig. 1.

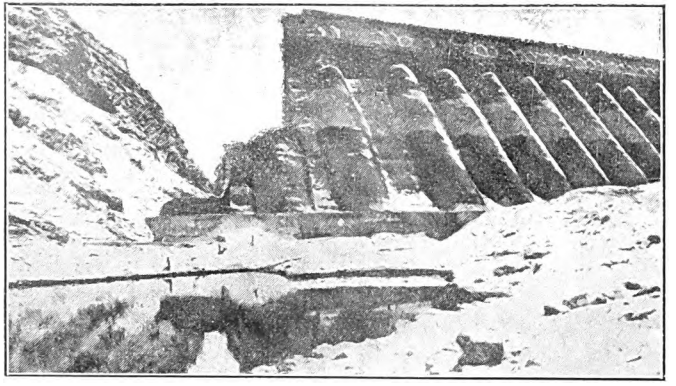

Fig. 2.

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In the examination of the constructional methods used there appear to be many faults.

Nothing was done to prepare the surface of the foundation rock to receive the structure. No steps were cut, nor was the surface roughened to receive the bond. The rock surfaces are described as so smooth that mortar could not adhere.

Although the specifications called for cement mortar, much of the masonry of the gravity base was constructed in lime mortar, of lime burnt near the site by the builders. The upper portion of the base was constructed in cement mortar. The concrete of the cellular superstructure was of poor quality, the gravel aggregate was not washed and the concrete in the structure was porous. The concrete was mixed by hand. Nothing is said of the proportion of cement to aggregate used, but the conclusion may be drawn that the mixture used was very weak in cement.

The reinforcement used was inadequate, that in the buttresses was scrap netting used during the war for protection against hand grenades. The bond of the concrete to the steel was injuriously affected by large stones thrown into the concrete during construction. As a further proof of the low strength of the concrete is the fact that the reinforcement generally stripped quite clean.

The faults in construction may be summarized as follows: (1) Failure to cut footings in the rock for the buttresses of the dam, (2) Use of improper materials and lack of inspection of materials, (3) Poor mixing and lack of inspection of the concrete, (4) Use of unwashed aggregate, (5) Lax inspection in pouring the concrete, (6) Failure to ram the concrete in the forms, (7) Generally incompetent direction and supervision.

Failure occurred about six weeks after the reservoir had reached its full level and is attributed to buttress shear, owing to the weakness of the material used in construction.

Even before the accident the buttresses probably contained shear cracks indicating incipient failure. There may or may not have been causes inciting the failure, such as the leaching out of the lime mortar from the masonry base causing settlement or the slipping of the masonry base on its foundations, either of which would have increased the already serious stresses in the buttresses to a fatal degree and brought about destruction.

The absence of efficient specifications or the neglect to follow such specifications if they did exist during construction was the true cause of the disaster.

D.K.E.

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# MEMOIRS.

## MAJOR-GENERAL SIR GEORGE KENNETH SCOTT-MONCRIEFF, K.C.B., K.C.M.G., C.I.E., M.I.C.E.

By the death of Sir George Scott-Moncrieff the Corps has lost a very distinguished servant and a greatly-valued friend and comrade, a fine officer and an eminent engineer, whose life was one of whole-hearted loyalty and unstinted industry in the service of the Crown, and of the Corps which ever held a foremost place in his pride and affections.

He was born in India in 1855, second son of Major Alexander Pringle Scott-Moncrieff and Elizabeth Coventry, his wife, and was a grandson of Robert Scott-Moncrieff of Fossaway, and nephew of that distinguished engineer, Sir Colin Scott-Moncrieff.

At the time of the mutiny of the Bengal Army in 1857, Major Scott-Moncrieff being absent on duty with the 44th Bengal Infantry, his wife, a woman of great courage and determination, escaped with her three children from Purulia, Chota-Nagpur, to Calcutta. His father died in 1865, and from shortly after that time till 1913 his mother lived in the family dower-house, Elie Castle, in Fife.

George Scott-Moncrieff was educated at Edinburgh Academy and at the Royal Military Academy at Woolwich, entering the Royal Engineers in 1873, and leaving Chatham in 1876.

His first employment was on the Thames Defences at Gravesend, chiefly on railway and jetty work, for landing heavy guns. He designed a large T-pier in the Thames at Shornmead.

In December of the same year he proceeded to India, and in February, 1878, was appointed Assistant Engineer in the Indian Public Works Department on the Swat River canal and employed on the design and construction of several large masonry works, aqueducts and bridges.

The year 1878 gave him his first chance of active service, in the Afghan campaign, in which he was present at the capture of Ali Musjid, and throughout the operations did a lot of important work, including the construction of twenty miles of the road from Cabul to Peshawur.

When Sir Sam Browne's force marched down from Afghanistan in June, 1879, a mass of R.E. stores were collected at Jellalabad, and transport having broken down, hundreds of little rafts were constructed, under the orders of the C.R.E. (the late General Sir Frederick Maunsell), from *mussaks* and telegraph posts, and were

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Major-General Sir George Kenneth Scott-Moncrieff, K.C.B, K.C.M.G., C.I.E.

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floated down the Cabul river to Dakka, each under the charge of two sappers. The night before the work was finished the men of Jellalabad, furious at losing the loot, attacked the fort, but made no impression. Scott-Moncrieff was one of the four or five subalterns kept by the C.R.E. for this work, and when it was finished they embarked on the last raft and made the passage to Dakka in about eight hours, through extraordinarily interesting scenery, partly through a gorge with vertical cliffs about 1,000 ft. high on either side, and, high up on one side, like pigeon-holes, could be seen the caves that Buddhist monks had burrowed for themselves in the cliff, the only access being by ropes from far above.

For his services in this campaign Scott-Moncrieff was mentioned in dispatches, and received the medal and two clasps.

From December, 1880, to October, 1882, he was stationed at Jutogh, near Simla, where he designed and erected many new barracks, hospitals, and other buildings, and constructed some new roads. In 1882 he became Executive Engineer of the Lucknow Division, building new barracks there also.

Appointed Deputy Consulting Engineer for Guaranteed Railways, Lucknow, in April, 1883, he was selected, after six months in that appointment, to be Personal Assistant to the Engineer-in-Chief of the Sind-Peshin State Railway, and the next year we find him in charge of the Quetta Survey Division, laying out the line from Quetta to Garkai (33 miles). After that he was Executive Engineer of the Nari Division of the Sind-Peshin Railway, which included two large bridges, sixteen smaller bridges and a tunnel.

In 1885 he was promoted Captain and invalided home, and in 1886 his marriage took place. His wife, Helen Morin, youngest daughter of Robert Moubray of Naemoor, was a lady of great charm, and had been the friend of his boyhood. The marriage was one of abiding affection, and of closest mutual interest and sympathy. Of the happy home life we may not speak, but that it was bound up with his love for the Corps appears from the words of the eldest of their six daughters: "The 'Corps' has always been to me a symbol of all that is greatest and best and most worthy of loyalty."

In 1886–7 he was employed at Colchester, but in the latter year he was given command of the 12th Field Company, and held it till December, 1891. At the Curragh he carried out the remodelling of the drainage of the barracks. The company was at Aldershot during the later part of his command.

In 1893 Scott-Moncrieff was promoted Major, and appointed Instructor of Military Engineering at the S.M.E., remaining till December, 1898, in that appointment. During this time he published two volumes on *Structural Design*, and a splendid book on *The Water Supply of Barracks and Cantonments*. These became text books of the course. He was the originator of the *R.E.*

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*Field-Service Pocket-book*, a work of which he was justly proud. He had previously written an excellent pamphlet on *The Frontier Railways of India.*

In 1892 he became a member of the Institution of Civil Engineers, his sponsors at his election being Sir Guilford Molesworth and Sir Colin Scott-Moncrieff. In 1917 the Institution conferred on him Honorary Membership, a distinction which he greatly valued. The records of the Institution show his ability and the variety of his engineering interests, by his useful intervention in the discussions on the Water Supply of Liverpool, Stresses in Masonry Dams, Road Construction and Maintenance, and again on Wind Pressures and Stresses Caused by Wind on Bridges.

On leaving Chatham he returned at once to the P.W.D. in India and was given charge of important work on arterial roads on the Frontier. There he got into touch with leading Mahommedan *maulvis*, and through them created a considerable interest in the Bible, copies of which, in Pushtu, he distributed.

In 1900, at the special request of the Viceroy, who had been impressed by his ability, he was sent in command of the Royal Engineers with the Indian Expeditionary Force for China. He took part in the relief of Pekin and in the actions at Peitsang and Yangtsun, was mentioned in dispatches, awarded the C.I.E. and given the China medal.

In 1901 he was promoted Lieut.-Colonel, and on his return to India was appointed Chief Engineer of the N.W. Frontier Province and Secretary to the Chief Commissioner, but in 1901–2 we find him again on active service with the Waziristan Expedition. He received the medal and clasp.

Of this period one of his brother officers writes: "What I noticed about Scott-Moncrieff was the strength of his religious convictions. He never started the day, however early, without reading a portion of the Scriptures. He had great physical energy and endurance. After long days in the saddle, or on foot, he would tackle correspondence or any business which came along till quite a late hour of the night."

In 1904, being made Bt. Colonel, Scott-Moncrieff reverted finally to Home service, and was appointed C.R.E. at the Curragh, where he was held in high estimation by General de Courcy Morton and given every opportunity for improving the work of Field Companies with cavalry and infantry.

He was known also as a good man to hounds, with a great heart for a big bank. An officer writes: "I commanded a field company at the Curragh when Sir George Scott-Moncrieff was C.R.E. there. He struck me always as being the ideal C.R.E., equally at home in soldiering and engineering, and obviously a power with the G.O.C. and Staff. He saw to it that we got plenty of jobs both on

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"Works" and in Brigade and Divisional trainings, but was by no means a believer in all work and no play. We never had any difficulty in getting leave for hunting. He was out himself often with the Kildares, and we used to chaff him on the number of times he had 'crashed' on his top-hat, saying that he did not seem to think that he had a good day unless that had happened.

"It must have been due to him that we got some excellent experience of bridging expedients with the 3rd Cavalry Brigade (General M. Rimington), at Lusk and at Bannow. These manœuvres finally took the form of squadron and horse artillery competitions across wide tidal inlets, with a pretty heavy current. Each squadron and battery was directed by Rimington to a point where stores were laid out and had to get horses and men across, using catamarans, hay-bale rafts, extemporized boats, etc. The contests were most exciting and interesting." The same officer bears witness to Scott-Moncrieff's keenness for engineer reconnaissance and also to the excellence of his winter lectures to officers and men of the companies.

On the 1st October, 1906, he was promoted Colonel and posted to the War Office as A.D.F.W. In 1907 he was awarded the C.B. The officer quoted before speaking of this time also says: "I owe him a very valuable bit of experience (when I was still O.C. Field Company), in connection with the installation of the Cavalry School at Netheravon in 1907–8. It consisted in the moving from Bulford and re-erecting at Netheravon a number of huts, buildings and stables, also installing a water-supply and sewerage scheme by sapper labour, supplemented by infantry working parties in the earlier stages and civilian labour later on. It was really a contract, and we did the job with a considerable saving on the estimate."

In August, 1909, Colonel Scott-Moncrieff was made Chief Engineer at Aldershot, with the temporary rank of Brigadier-General. There he remained, again making his mark by the excellence of his work and administration till, in September, 1911, he was selected by the Army Council for his last appointment, Director of Fortifications and Works. He was promoted to Major-General in October, 1912.

The incidence of the war and his own proved fitness for his great charge caused the tenure of his appointment to be extended till February, 1918, when he had to make way for Sir P. G. Twining and finally retired.

For his services in the war he received the K.C.B., the K.C.M.G. and the medal. He has himself written full accounts of the work carried out in his office during this strenuous time. It must, therefore, only lightly be reviewed in this memoir. It is not too much to say that Scott-Moncrieff's cool and balanced judgment, his ability and experience, together with his extraordinary industry, were of vital importance to the War Office during the course of the war till he handed over. A part of the work was closely affiliated to that

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of the Quartering Branch of the Q.M.G.'s Department, and those who were in that Branch can gladly bear witness to the cordial and kindly relations which throughout were maintained, and to the ready assistance and advice always available in the office of the D.F.W.

An officer, serving under him at this time, being also his intimate friend, writes :—

> " It was during these fateful years that we were almost hourly in contact and no one will ever know how much work he got through and how his indomitable spirit and absolute dependence upon God for everything sustained him through untold pressure and deep family sorrow.
>
> He was usually surrounded by members of his staff and others waiting for interviews or ' decisions ' and he was always alert and quick to decide whenever questions were referred to him.
>
> His judgment was sound and definite and once given was ' carried through.' There was no time for hesitancy and his wide knowledge and experience of all engineering questions and official routine instilled confidence into his staff, whom he absolutely trusted and who had the fullest confidence in their Chief."

His connection with the Institution of Civil Engineers was one of great avail at this crisis, and he was able to draw in the power of a number of civil engineers and to secure the services of many of the leading contractors.

His own accounts of the work are recorded in a series of articles contributed to the *Times Engineering Supplement* in the early part of 1919. Later on he published in *Blackwood's Magazine* (to which he was a frequent contributor) reminiscences of his association with Lord Kitchener before and during the war. There is also in the present number of the *R.E. Journal* an article of his on the hutting problem of the war, which gives in detail the work from the aspect of his office, and shows the magnitude and interest of the service.

The supply of engineering stores to the armies in the field gave him much urgent thought and necessitated visits to France.

The illness of his wife and her passing away in November, 1916, the result of terrible injuries received more than a year before, by being knocked down by a motor-car, brought crushing anxiety and sorrow upon Scott-Moncrieff, at a time when his work in the great war was at its heaviest, and saddened and aged him.

On his retirement he joined the Board of Messrs. Macdonald Gibbs & Co., and, in connection with " English Oilfields," set to work on the development of the shale oilfields near King's Lynn. This work he continued till, in 1921, failing health obliged him to curtail his activities. His great sorrow, and the ceaseless work and devotion to duty of the years of the war, had weakened his vitality

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and his medical adviser now warned him that his heart was badly overstrained, and that, unless he took the greatest care, he must not expect his life to be prolonged for many months. Characteristically he accepted the verdict with a smile, saying that he hoped to be able to work till the end should come. He was always ready.

To his friends he seemed to be getting better, and there was no slackening of his religious work or in his Corps interests.

His loss will be specially felt by the Central Committee of the R.E. Old Comrades' Association and by the Charitable Fund, of both of which he was chairman.

He took an active part in the reconstitution, under the Royal Charter, of our Institution, of which he was elected one of the Vice-Presidents; and was deeply interested in the development and improvement in the *Journal*.

His fellow-members of the Councils and Committees of the Corps will unanimously testify not only to his unfailing good-humour and courtesy, but also to the innate generosity of his views, especially in dealing with personal matters. He seemed to bear the whole world in affectionate remembrance. The sterling quality of his advice and of his opinions made them always acceptable, while the deep tones of his voice, and the ready smile and humour behind his somewhat serious aspect, weightily impressed his hearers.

The end came suddenly in Poland, whither he had gone in the interests of the Society for promoting Christianity among the Jews.

A brother officer writes: "Thus he died as he would have wished, working for the cause of the Saviour Whom he had consistently served all through his life. Deeply religious, he was no narrow sectarian, but a true exemplar of the gallant and happy fellowship to which so many of our greatest Anglo-Indian soldiers and civilians have belonged."

When duty had brought him home to England, he was welcomed on the Boards of the Church Missionary Society (of which he was a Vice-President, and a very active member), and of the British and Foreign Bible Society.

He was the author of *Eastern Missions from a Soldier's Standpoint*, and for fourteen years he compiled the monthly Missionary Leaflet for the Officers' Christian Union, embracing a view of practically every missionary operation in the world. Even in the stress of the world-war he never failed to produce a comprehensive epitome of the missionary activities of the Church of Christ, in itself a monument of research and industry.

He leaves to the Corps and to his many friends a memory fragrant with loyal service, kind words, unswerving friendship, tireless industry, and a record of high principle fulfilled in every interest of his life.

F.G.B.

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## *COLONEL WILLOUGHBY DIGBY MARSH.*

COLONEL W. D. Marsh, who died at Thomas Town, Co. Kilkenny, on 19th May, 1924, in his 93rd year, was the oldest surviving officer of the Corps, with which he was connected for nearly 75 years, 40 of which were on the active list.

He retained the use of all his faculties almost to the end, though latterly troubled by failing eyesight. He was a keen fisherman and killed his last salmon a few years ago, unaided and with a foot of snow on the ground.

Born in 1831, the eldest son of Rear-Admiral Digby Marsh, he was educated at Blundell's School, Tiverton, and entered the "Shop" at the age of 15. He passed out Head of his Batch and was gazetted 2nd-Lieut., R.E., on 19th December, 1849, being promoted Lieut. in 1854, 2nd-Captain 1858, Captain 1864, Major 1872, Lieut.-Colonel 1874, Substantive Colonel 1885, and placed on the retired list in 1889.

Colonel Marsh was unlucky in missing the "Crimea" and the "Mutiny," spending those eventful years in the West Indies, where he was stationed from 1852 to 1857, at St. Vincent, Trinidad and Barbados. At the last named place he served through a severe epidemic of cholera, which carried off many of the inhabitants and of the Garrison.

At various stages in his career he was employed on "Works" at Woolwich, Chatham and London. He was also an Instructor in Survey at Chatham from 1861 to 1865, and attached to the I.G.F.'s Office from 1865 to 1870. His eyes suffered much at this period from the bad lighting of his office, but after a period of rest and attention they recovered.

From 1875 to 1884 Colonel Marsh was at the "Shop," first as Professor of Military Drawing and later as Secretary and Treasurer, being "Acting Governor" on several occasions. This long spell of duty at the R.M.A. caused him to be well known to a very large number of the officers of the R.A. and R.E. commissioned during those years; one of his pupils was the Prince Imperial.

His last appointment was Colonel on the Staff, C.R.E., in Ireland. Whilst holding this appointment he was made a J.P. owing to the disturbed state of the country. It does not appear, however, that he was ever called upon to read the Riot Act or to call out the military.

Shortly after leaving the service in 1889 he settled down in Kilkenny.

Colonel Marsh had a wonderful memory. With his elder sister, who is still living, he saw his brother (afterwards killed in the Crimea) carrying the Colours of the Duke of Wellington's Regiment at the Duke's funeral. He was a contemporary and intimate friend of General Gordon, and loved to recall incidents in the latter's career.

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**Colonel Willoughby Digby Marsh.**

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Colonel Marsh was an artist of very considerable talent as well as a skilful carpenter and a good shot and fisherman. He was a devoted Christian, courteous, considerate and always anxious to help everyone around him; a gentleman in the best sense of the word, he will be long remembered by all who had the privilege of knowing him.

He leaves two surviving sons and one daughter, married to the Hon. H. A. Shore.

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## *COLONEL GEORGE ANDERSON CARR.*

COLONEL George Anderson Carr, who died on 20th March, 1924, was one of the pioneers of electrical science in the British Army. Born in 1857, he was the son of William Carr, Esq., of Nymans, near Crawley, Sussex. He was educated at Uppingham and the Royal Military Academy, Woolwich. He obtained his first commission in the Royal Engineers in August, 1876, and after two years of instruction at the School of Military Engineering, Chatham, he was posted to the Submarine Mining Service, with which he was employed at Chatham, Sheerness, Portsmouth and Pembroke Dock. In 1883 he was appointed Assistant Instructor in Electricity at the School of Military Engineering and in 1886 was transferred to the School of Submarine Mining, which was just being reformed at Gillingham.

He was promoted to Captain in 1887 and in 1889 went to Bermuda for his first foreign service. He was recalled from there in 1892 to take up the new appointment of Chief Instructor at the School of Submarine Mining, Gillingham, and in 1896 was appointed Instructor in Electricity at the School of Military Engineering, having been promoted Major in 1895. In 1902 he was posted, on promotion to Lieut.-Colonel, as C.R.E., Cape Colony. Here he came in for the last few months of the South African War and received medal and clasp.

He retired at his own request in March, 1909.

Colonel Carr married, in 1888, the eldest daughter of the Rev. R. P. Hooper, of Hove, and had two sons, both of whom obtained commissions in the Corps of R.E.

The above is a short summary of a very active and useful life and a few words may be added to fill in some of the details. Like many other young officers, Carr passed easily through his various courses and examinations without any special distinction, but when posted to the Submarine Mining Service he found employment which was entirely congenial, and well adapted to his special qualities and character. Possessed of a remarkable capacity for clear and accurate thinking, he added to this an infinite capacity for taking pains. With him nothing was ever half-done; if he started any job he threw him-

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self into it whole-heartedly. In his new work he found himself in company with a little group of officers who were laying the foundations of a new application of science to military purposes. Chief among these were Major R. Y. Armstrong, R.E., Lieut. P. Cardew, R.E., and Lieut. (now Major-General Sir R. M.) Ruck, R.E. Under these officers it fell to Lieut. Carr to carry out many detailed experiments, to elaborate electrical apparatus, and to devise methods of testing which could be readily applied in the rough and tumble of military work. He was the first to suggest the fitting up of standard test rooms at military defence stations so arranged that the position of all firing and testing apparatus would be identical in each station.

He was Secretary of a special committee in 1880 which reported on the patterns of apparatus in use for searchlights, which laid the foundations of that branch of the military service.

As an Assistant Instructor and Instructor in the Electrical School, S.M.E., he was responsible for the instruction of military telegraphists, and for the instruction in signalling of all ranks.

As an instructor and lecturer he was at his very best. He not only had the habit already referred to of clear thinking, but the capacity of putting his thoughts in logical sequence and expressing them in clear and simple language adapted to his audience. He was for many years the examiner in electricity at the Royal Military Academy.

In connection with his various appointments he held for different periods an *ex officio* position as Member of the Royal Engineer Committee, and was at one time Secretary. This committee worked through sub-committees, which investigated and often originated proposals for changes in the construction or use of all military engineering stores and appliances. Carr was a member of all the electrical sub-committees and was often called on to act as Secretary or for special work, such, for instance, as the standardization of patterns and sizes of screw threads in use throughout the Army. He attended as a member of this committee the early trials of Marconi on Salisbury Plain, and at Poole in 1895, and formed a personal friendship with Signor Marconi.

He became an associate member of the Institute of Electrical Engineers in 1882 and served on the Council of that Institution in 1895–96. He was admitted to full membership in 1896.

To those who knew him well he was a most interesting companion, as he had read and studied much and generally took some original and often illuminating view on any controversial question. Though interested in games and playing those he took up well, he only treated them as a recreation. But perhaps his most marked characteristic was a deep-seated modesty as to his own qualifications. He never put himself forward for any of the appointments he held, or asked any favour as to employment. It was perhaps unfortunate both

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for himself and for the Army as a whole that his period in the rank of Lieut.-Colonel should have been spent in the comparative seclusion of Cape Colony, so that he dropped out of the running for a senior appointment in England.

Major-General Sir Richard Ruck, K.B.E., C.B., C.M.G., writes:—As I was closely associated with Colonel Carr in the early days of submarine mining, I should like to say a few words in support of your appreciation of his work and character.

The Corps of R.E. was very fortunate at that time in possessing officers of the type of Colonel Armstrong, Major Cardew and Colonel Carr, men of first-class intelligence combined with real scientific ability and an absorbing devotion to their work.

These officers, with one or two others, were (as you remark in the case of Colonel Carr) the pioneers of electrical science in the British Army, Colonel Carr being, I think, pre-eminently the instructor and perfector of the electrical methods and appliances which were not infrequently in those days of a makeshift nature.

In common with all who were associated with Colonel Carr, I had the greatest possible respect for his sense of duty, knowledge and ability, and one could not wish for a more loyal and careful assistant.

His work in connection with the electrical side of submarine mining was invaluable, and his general career one of great utility to the Corps to which he was proud to belong.

W.B.B.

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## *COLONEL HUGH MONTGOMERIE SINCLAIR, C.B., C.M.G., C.B.E.*

Colonel H. M. Sinclair, late R.E., died suddenly at Barming House, Maidstone, on the 10th July, 1924. The fifth son of Canon William Sinclair, who was formerly a captain in the Madras Cavalry and afterwards rector of Pulborough, he was born in 1855 and was educated at Malvern and Repton and at the R.M.A., from which he passed into the Royal Engineers, gaining the Pollock medal, in February, 1874. After short tours of service at Chatham, Dover and Aldershot he went to Cyprus on its occupation by the British in 1878 and remained there for eight years, during the last five of which he was private secretary to the High Commissioner. He served in Ireland from 1886 to 1888 and then went to the Staff College, from which he graduated with honours in 1890. From 1890 to 1892 he was employed at the War Office and then obtained the appointment of D.A.A.G., North Eastern District, which he held until 1895. He was again at Aldershot in April, 1895, and from there he went as C.R.E. to the Ashanti expedition, for which he received the Star and Brevet of Lieut.-Colonel.

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He served in India from 1896 to 1899 and then became A.M.S. and A.D.C. to Lieut.-General Sir George Luck, Commanding in Bengal, but threw up the appointment a year later to take part in the South African war, where he was employed on transport duties, graded as A.A.G. He took part in the operations in the Orange Free State, February to May, 1900, in the Transvaal east and west of Pretoria, July to October, 1900, including the battle of Zillikats Nek, and in Cape Colony, South of Orange River, and was mentioned in dispatches. He returned to India for two years, was C.R.E. Woolwich 1902–3, A.Q.M.G. Western District till 1907, A.A.G. Southern Command (1907–8) and Chief Engineer Scottish Command until he retired from the service in February, 1912. In 1906 he married Rosalie Sybil, second daughter of Sir John Jackson. He received the C.B. in 1910.

Colonel Sinclair settled near Maidstone in 1912, but on the outbreak of the Great War he was appointed Commandant of Railways and Roads Training Centre at Longmoor and held the command until the end of 1919. He received the C.M.G. and military C.B.E. as rewards for his services. During the last years of his life Colonel Sinclair entered keenly into the religious work of his village and of the Rochester Diocese, and he will also be gratefully remembered for his share in the work of the R.E. War Memorial Committee, in which he was Chairman of the Monument Sub-Committee, and devoted much time to the selection of the site for the R.E. Memorial, the preparation of the Roll of Honour and the work in the Kitchener Chapel in St. Paul's Cathedral, where the Corps is presenting the altar and providing a niche for the Roll of Honour. It is not the least regret of those who were associated with him in this latter work that he has not lived to see it completed.

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## *COLONEL HARRY D'ARCH BRETON.*

COLONEL HARRY D'ARCH BRETON, late R.E., whose death took place at Rochester on Friday, 19th July, was the son of the late Captain W. H. Breton, R.N., and was born at Bath in 1851. He entered the Corps in 1871, and during his 33 years of service he was employed for over 14 in the I.G.F.'s office at the War Office, including nearly five as Assistant I.G.F. (1899 to 1904). He was not fortunate enough to see any active service and had only one tour of foreign service, which he spent at Saint Helena, as a Captain (1876–1881). He retired in 1904 and settled at St. Margaret's House, Rochester, where he threw himself heart and soul into municipal activities. In 1914 he became mayor of the ancient city, so well known to all members of the Corps, and he was still Mayor of Rochester when

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we held our Memorial Service in the Cathedral in 1919. Throughout all the anxious years of the War his services to the Borough were untiring and invaluable, and no small strain upon a man no longer young. His last years will be chiefly remembered for his efforts on behalf of the ex-Service men. He was an example of the grand type of old English gentleman, courteous to all, a good companion and universally popular.

## *BOOKS.*

### EAST PERSIA: A BACKWATER OF THE GREAT WAR.

By Brigadier-General W. E. R. DICKSON, C.M.G., C.I.E. (Edward Arnold & Co. 15s. net.)

GENERALLY speaking, a book written by an R.E. officer on engineering subjects is interesting. When to these subjects are added solved problems in Strategy, Transport and Administration, then such a book becomes absorbing, and such a book is General Dickson's *East Persia: A Backwater of the Great War.*

General Dickson's account of this "backwater" has already been favourably noticed in the Literary Supplement of *The Times*, which draws attention to the fact that the Government of India, with its G.H.Q., frequently displays the faculty of fitting round holes with well-turned round pegs. In this case there was appointed, as I.G.C. of the L. of C. in East Persia, a soldier who was experienced as an Engineer, as a Staff Officer, and as a linguist in Persian and Russian.

The book is a "workshop record" of the conversion of a loose net (called the "East Persian Cordon") into a close-meshed sieve (called the "East Persian Line of Communications"), which was designed to intercept Turco-German emissaries (*en route* to intriguing in Afghanistan) as well as to continue the throttling of the traffic in rifles between the Persian Gulf and the N.W. Frontier of India.

The future historian will no doubt grumble that this same "workshop record" is unworkmanlike in that it omits to state the *years* of the happenings. For instance: he will be unable to ascertain when General Malleson's Mission went to Meshed, or when the author went to East Persia, or when the great road was begun and when finished, or when the Quetta railway was pushed on to Persia. This failure to indicate the *years* in which events occurred is one of the commonest (and, one may say, the most exasperating) of faults in all the unofficial histories of the many theatres of the war.

Before the mid-period of the war, our line of approach to the South-East corner of Persia, *i.e.*, Seistan, was a veritable "pilgrim's-way" from the railway terminus at Nushki (which is about 100 miles south-west of Quetta) across about 300 miles of desert lying to the south of

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Afghanistan. By dint of the superhuman energy of its Engineer-in-Chief, the railway had been pushed on across this desert to within 100 miles of the Persian border when General Dickson took over charge as I.G.C. in E. Persia, and it was finally carried through to Duzdap, from which point General Dickson made his great road which stretches 600 miles to Meshed, in the north, and runs parallel with the western boundary of Afghanistan and approximately 80 miles from it. From Meshed to Askabad, 170 miles to the north-west, a good carriage-road had been made by the Russians. This road also came within General Dickson's L. of C., which, therefore, was 870 miles in length, or about the distance from Boulogne to Vienna, or from Karachi to Landi Kotal (at the top of the Khyber).

This mere recital of distances would not impress the mind without such considerations as the nature of the country (deserts, quagmires, shifting sand and stony ranges), the difficulties of climate (terrible heat and appalling sandstorms in many sections, and icy blizzards in many others), the lack of *personnel*, skilled or otherwise, and the want of "straw" for the "bricks." Added to these great obstacles was the need to evolve, and to evolve at racing speed, order out of the chaos which the inception of our first efforts in East Persia occasioned. How a "man of mettle" may "grasp" such "thistles" in the path of progress General Dickson tells in simple, clear and modest language, much of which is devoted to giving credit to the whole of his loyal band of workers, from the late Colonel Mark Synge (a Napoleon of Supply and Transport in wild regions) down to the M.T. driver, who postponed his own comfort and demobilization so as to motor General Dickson on his final and farewell tour before giving over command.

From the point of view of the R.E. reader, it is rather unfortunate that there are no descriptions of the methods adopted for the crossing of ravines and streams, whether these were negotiated by Inglis bridges, steel girders, arched masonry, or suspension work.

However, what we lose on the Engineering we gain on the Transport, a subject which is dealt with in a novel and interesting way. The first principle, as it occurred to General Dickson, and as it was developed by Colonel Mark Synge, was that the Troops and Services were "consumers," and the Transport was the "producer," of a commodity called "transportation energy." The unit of "transportation energy," applicable to consumer and producer, which was selected by these two officers was the moving of one ton, once a week, over a distance of one mile, and it was designated "WTM." As it would seem like pilfering to reproduce, in a review, the working of this scheme, which is adequately explained in the book, it will suffice to say that the WTM of a camel worked out at 6 tons, and that of a Ford van at 46 tons, after allowing for rest and repairs. By compiling, and having at hand, a sort of "ready-reckoner" table, showing the needs of the various arms, and units, in tons, and showing also the various distances and the WTM value of the classes of transport available, it was easy to answer, with speed and accuracy, the conundrums from G.H.Q., and to deal with varying demands of the L. of C.

General Dickson completely justifies his action in expending money

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on hutting the troops, etc., on his L. of C.—an expenditure which was hysterically condemned by ill-informed newspapers, but an expenditure which saved the whole of the Force from serious losses, when death and disease lurked in the Persian " billets," which these same newspapers would have had our men inhabit—.

One of the most important points brought out in the book is the establishment of excellent relations between the Persians, of the whole of the lengthy locality, and our own people. This admirable result was due to the irreproachable behaviour of the troops themselves and to the faultless tact of all our officers, who were always just in their firmness and wise in their toleration. The effect of such relations on the trading between East Persia and India has already been considerable, and, especially as the imports from Bolshevist Russia have dropped by 80 per cent., it seems most likely that the whole cost of our occupation of East Persia will be recouped by our increased trade in the very near future.

General Dickson saves his book from being merely a serious record by many " human " touches and by humorous stories of Oriental guile and simplicity. Not many of us have had an invitation-card marked " Hanging and throat-cutting at 4 p.m. on the Execution Square."

G.P.C.

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## THE ARMY IN INDIA, AND ITS EVOLUTION, 1924.

(Superintendent, Government Printing, India.)

As specified in its prefatory note, the principal purpose of this admirable work of reference is to provide a contemporary account of the reorganization of the Army in India since the Great War, and to describe the essential features of this reconstructed army.

The book is also intended for the information of the general public, and for use in promotion examinations, and although it has been compiled officially, and with the authority of the Government of India, it is not wholly a formal " Official Publication." Consequently, the author, or authors, adopted an attractive and simple method of compilation which has created that most desirable of qualities, " easy-reading."

The first chapter, which is entitled " Historical Retrospect," is a text-book in itself, and an interesting text-book, free of laboriousness and of unnecessary statistics. Nevertheless, the sources of its information are " weighty authorities," so that it is all thoroughly reliable.

It is not possible, in the space at disposal, to do full justice to even one of the many chapters, or to say that any of these is better than its fellows, when all are excellent.

The book is made up chiefly of four Parts, of which the following is a brief summary :—

*Part I* contains the above-mentioned " Historical Retrospect," and recounts the lessons of the Great War, and the details of the subsequent reorganization and of the Administration and the High Command.

*Part II* provides separate chapters for the respective descriptions of all the links of the Army-chain, *e.g.*, Staff, British Cavalry and Infantry,

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Royal Artillery, Royal Engineers, Indian Cavalry and Infantry, and the Ancillary Services, as well as describing the Indian State Forces, and the Supply of Officers.

*Part III* is devoted to the Royal Air Force in India.

*Part IV* deals with the Finance of the Army and of the Royal Air Force in India.

But these main portions of the book do not exhaust its wide information or its interest, as there are no less than 21 Appendices, all of which are very neatly arranged. One of these will be studied many times by officers of every branch of the Service, as it contains a startling contrast between ancient and modern forms of transport, as shown below :—

A Force of 4 Divisions (with animals only on half-rations) requires a daily lift of 900 tons. Such a lift would require one or other of the following alternatives :—

| *Type.* | *Number required.* | *Radius (miles).* | *Road-space (miles).* |
|---|---|---|---|
| Broad Gauge Trains ... | 1 | — | — |
| Light Railway Trains ... | 3 | — | — |
| 3-ton Lorries ... ... | 300 | 30 | 6 |
| 3-cwt. Lorries (pneumatic cord tyres) ... ... | 600 | 40 | 16 |
| Ford Vans ... ... | 2,500 | 50 | 42 |
| A.T. Carts ... ... | 3,150 | 10 | 13 |
| Camels ... ... ... | 45,000 | 10 | 126 (single file). |

Naturally, the chapter on the Royal Engineers (including the Sappers and Miners, and the Engineering Services) will appeal most to the readers of the *R.E. Journal*, and particularly to those who contemplate an Indian career, or even a tour in India. The diagrams showing the new systems of R.E. chains of command (at Head Quarters and in the four Commands) are reproduced in the Appendices, and have already appeared in the *Supplement to the R.E. Journal.*

G.P.C.

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## INDIA: A BIRD'S-EYE VIEW.

By the EARL OF RONALDSHAY, P.C., G.C.S.I., G.C.I.E. (Constable & Co. 1924.) Price 18s.

WHAT every intelligent traveller in a country first desires is an immediate bird's-eye view of it, pending the slowly-acquired knowledge of Experience.

But this "viewing" must not be what the guide-book uses, namely, a mere glance accompanied by a catalogue of the visible "prominences." It must see *into* the material things, and must discern the spiritual in the tangible, and yet it must not cause the eyes to tire, or the brain to ache.

Possibly some such idea urged Lord Ronaldshay to write this admirable book, which is warmly commended to every officer whose career is, or is to be, in India.

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Lord Ronaldshay, who was recently Governor of Bengal, has not only travelled far and wide in Asia, but he has written half a dozen other books on the East, and is probably the best-informed of all our writers on India.

In the first place, this book is literature, and, for this reason alone, it is a joy to read. Furthermore, its many indications of wide culture and sound research will appeal to all scholars. Its only blemish is that the attractiveness of the chapter-headings tempts the reader to "browse" (as one does in a library) instead of reading in orderly sequence, and thus appreciating the later "references." But even such "browsing" will soon show the reader that this comprehensive, but compact, book will readily engage the close attention of the soldier, as well as being of the utmost interest to the "Indian-Civilian" and the English-Statesman.

For instance: Every military officer, and especially every R.E. officer, in India, has frequent dealings with natives of all classes and religions, and must exercise considerable circumspection so as to avoid offending the caste-prejudices and the religious susceptibilities of his local co-workers, subordinates and social acquaintances. A careful perusal of Lord Ronaldshay's accurate descriptions of the races, creeds and customs of that "difficult" Empire will save even a new-arrival from most of the troubles which beset the Great Endeavour, *i.e.*, the "Bridging of the Gulf."

The author's broad-minded appreciation of Mahommedan and Hindu architecture does not dim his keen perception of the ornate *minutiæ*, and these together interpret to him the minds, beliefs and environment of those wonderful designers of a remote past. Again, in his treatment of any of the distracting "policies" of India, whether it be the "forward" policy of a frontier, or the "self-determination" policy of a Bengali-irredentist, or the Akali-policy amongst the Sikhs, he sees all of the little when describing the big, and he also provides sufficient data to enable a reader to form a policy for himself.

The graphic account of the N.W. Frontier of India, its history, its geography, and its ever-present military and political problems, are extraordinarily interesting.

G.P.C.

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## PERFORATED MAP. AN AID TO NIGHT OPERATIONS.

By Captain T. J. Edwards, The Somerset Light Infantry (Prince Albert's). Gale & Polden. Price 1s.

The importance attached to aids in night operations in future wars is stressed by General Sir George Milne, in a foreword, and this invention is an effort to assist such operations without the use of special gear. The principle of the perforated map is that a map or enlargement should be prepared for each night operation, the details being pricked through the paper according to conventional signs.

The system was adopted by the author's battalion for patrolling in Macedonia, and proved valuable.

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Without practical experiment it is hard to judge its efficacy, but the system would seem to be one which would require considerable training on the part of the users.

The idea is worth investigation, and, as the notes have been prepared as the result of practical experience in war, even if the whole system is not accepted, valuable hints as to the preparation of sketches for night marching will be gained from a study of the pamphlet.

W.P.P.-W.

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## ANALYTICAL MECHANICS.

By EDWIN H. BARTON, D.SC. (London), F.R.S., F.R.S.E., F.INST.P., F.P.S.L., Professor of Experimental Physics, University College, Nottingham, and sometime Examiner in Physics to the Universities of London, Birmingham and Manchester. Published by Longmans, Green & Co., 39, Paternoster Row, E.C.4. Price 21s.

THIS book of 21 chapters and 578 pages is a treatise on statics, particle and rigid dynamics, and there are useful chapters on mechanism, strains, hydrostatics, hydrokinetics and elasticity. Nearly the first half of the work is devoted to dynamics, and the treatment is to some extent novel, inasmuch as the theory of rectilinear and orbital motion is tolerably extensively developed as a branch of kinematics, that is, without reference to the laws of motion. There is much to be said in favour of this procedure and little if anything at all against it.

Kinetics and the Newtonian theory are not introduced until the XIth chapter, which opens with an interesting historical review, and extracts from criticisms on the Newtonian philosophy made by eminent mathematicians. Euler's equations are explained in Chapter XIV, and their important applications clearly developed; no mention, however, is made of Lagrange's equation or of theories of constrained motion and small oscillations.

Within the limits that the author has set himself, statics has been tolerably completely dealt with, the theories of forces in three dimensions, attraction and potential centroids are quite adequately treated.

There are but two short chapters on hydro-mechanics.

The examples have been chosen with great care, those following the various chapters are mostly from the London B.Sc. Pass Exam.; but there is an extensive collection of miscellaneous and much harder examples from the London B.Sc. Honours Exams.

The collection would be improved if some examples on tops and gyroscopes were added in a subsequent edition. Mathematical acrobatics have been avoided.

The study of the book requires a knowledge of the calculus; the treatise is intended to meet the requirements of University students, and is more than sufficient for the B.Sc. Pass Exam., London, in fact it contains a great deal of the knowledge required for the six papers of the Honours Exam. in mathematics at Oxford, Cambridge and London Universities.

Within the limits which the author has set himself, the information

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given is tolerably complete; Dr. Barton has preferred to omit certain parts of mechanics altogether rather than to deal inadequately with them.

A complete outfit of works on mechanics, including hydro-mechanics, would cost the student certainly over £10, whilst this treatise which contains a great deal of the subject matter of well-known standard works, costs but 21s.; the average student will probably find its purchase an economy and sufficient for his needs. The author is to be congratulated on having produced a very valuable all-round treatise at (in these days) a reasonable price. I can recommend its acquisition to any R.E. officer who, having a fair working knowledge of the calculus, desires to improve his knowledge of mechanics, or, having but few books, requires a handy volume for reference.

J. M. WADE, *Lieut.-Colonel* (B.Sc., London).

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## WHERE TO SEEK FOR SCIENTIFIC FACTS.

By A. B. EASON, M.A. (Cantab), A.M.I.C.E., A.M.I.E.E. W. Rentell & Co., Ltd. Price 1s.

THE object of this pamphlet of some 40 pages is "to indicate where people may find—(1) Lists of books on various science subjects, (2) Books or journals and proceedings and bulletins of learned and scientific societies; (3) Indexes of literature and publications and papers on technical and scientific subjects; (4) Abstracts of technical papers." It is intended "to help people from spending a long time in searching for information," and is little more than an index of catalogues and similar publications, such as the *Catalogue of British Scientific and Technical Books*, 1921 (compiled by the British Science Guild) and of libraries where the books may be found. In a list of periodicals on *electrical* subjects, the only list of periodicals given, we notice mention of our distinguished contemporary, *The Sapper*. For some unknown reason contributions dealing with electrical subjects do not often come our way, and it is perhaps deservedly that the name of the *R.E. Journal* is not mentioned.

F.E.G.S.

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MR. A. H. DYKES, M.I.C.E., M.I.E.E., has sent us a paper on "Electricity Supply in War-time as Affected by the Improvements in Heavy-oil Engines," written by himself and W. T. Townend, R.N., and published under the auspices of the Diesel Engine Users Association, 19, Cadogan Gardens, S.W.3. They call attention to the tendency to replace the existing smaller local stations by large capital stations, serving by means of high-tension feeder cables very large areas, and point out how impossible it is to camouflage such stations against air-raids if the power is obtained by the use of coal. Their conclusion is that the only practicable way is to provide a certain number of underground stations driven by heavy-oil engines. The project of the design of one of these stations is worked out in great detail, for which we must refer our readers to the pamphlet itself, a copy of which is being placed in the Corps Library.

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EARLY in the present month Messrs. John Murray will publish a new book by Major E. W. C. Sandes, D.S.O., M.C., R.E., entitled *Tales from Turkey* (Price 5/-). Those who are acquainted with his earlier book *In Kut and Captivity with the 6th Indian Division* and with his articles in the *R.E. Journal*, of which we are promised another, describing the Siege of Kut, will welcome the appearance of this new volume, which is reported to contain tales of adventure, intended to describe the strange people of a strange land—the Turks of Anatolia—with a few remarks on other nationalities found in Turkey.

## *MAGAZINES.*

### *THE JOURNAL OF THE ROYAL ARTILLERY.*

OUR readers will learn with interest that the Council of the Royal Artillery Institution has decided to follow the example set by the Royal United Service Institution and ourselves and to publish its journal in future quarterly instead of monthly. The first quarterly number is notified for publication on 1st October.

### *REVUE MILITAIRE GÉNÉRALE.*

(*April*, 1924.)—*The Peninsular War.* By Commandant Grasset.—The writer considers that a study of Napoleon's strategy in face of the national rising in Spain in 1808 may afford valuable lessons for the present day. It is hardly realized that, with her organized militia as well as a regular army, Spain then possessed what almost amounted to obligatory service. When the imperial troops invaded the country they soon found that they were in the presence of a nation, not, indeed, prepared for war, but provided with the essentials of a national army. Their position, therefore, in face of the national rising, resembled that of any European army which might now be occupying a country which has not yet completed its mobilization, but is animated by strong national feeling and hatred of the foreigner, which has arms and a respectable number of trained reservists or militia, or societies for military training. It is of considerable interest to trace the Spanish efforts to organize their forces in presence of the imperial armies, and to note the defects in the strategical action of the latter in spite of the fact that they began with many factors in their favour. In this number is described the inception of the rising in the North of Spain. (*To be continued.*)

*Our North African Races in the New Army.* The article by Lieut.-Colonel Clément Grandcourt is continued.—In this number he develops his argument in favour of the professional soldier and points out his economic advantages, considers the administrative and legislative measures required to attract recruits, ensure a fair proportion of re-engagements, and secure the continued loyalty of the old soldier after

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his discharge. He then discusses organization, which must differ in Tunis from that in Algiers. (*To be continued.*)

*The Military Apprenticeship of the Italian Army.* By Albert Pingaud.—French domination in Italy awoke the martial spirit in a nation which for three centuries seemed to have confined its energies entirely to the arts of peace. It was not until 1806 and 1807 that Italian troops were admitted into the "Grand Army." The participation of one of their divisions in the campaigns in Prussia and Poland represents their *début* in the political arena of the world, and their experiences therein form the subject of this article.

*Attack of the 10th Colonial Division in September, 1915.* The conclusion of the article by Commandant P. Janet.—At 1040 hours the 6th Corps (second line) advanced behind the colonial division, but, adhering strictly to their orders not to aid the latter in their task (they were to leap-frog the colonial division when the latter reached the Py), the leading brigades halted in rear on approaching the firing-line. Two groups of artillery sent forward failed to get into touch with the infantry and remained inactive. In the evening the Germans brought machine-guns into action, and for two hours opened a bombardment with gas-shell. The action was resumed next morning, but the favourable opportunity had been lost, and in this sector the German second position was nowhere breached. The causes of the failure are then discussed. Briefly they were the short aim of the French artillery, due to bad weather and breakdown of communications, absence of effective immediate reserves for the first line, the deaths of the divisional commander and of his two brigadiers, the mud, want of training in open warfare, and absence of accompanying artillery owing to the mules being killed. There was no lack of bravery and dash on the part of the troops.

*Was it a Mistake to Withdraw the Belgian Army on Antwerp ?*—A short rejoinder by Capt. Kuntz to Colonel Nuyten's article under the above heading (*R.E.J.*, June, 1924) which was written to demonstrate the fallacy of Capt. Kuntz's previous arguments in reference to Belgian strategy. The editors accept no responsibility for the opinions expressed.

*Military Chronicle of Economic Questions.* By Pierre Bruneau.—The appointment of General Debeney to the head of the staff will ensure the study by French Staff officers of economics, a course which he introduced when Director of the *Ecole de Guerre.* The increasing use of agricultural tractors gives cause for anxiety, in case it should lead to a reduction in the effectives of the infantry, which was recruited mainly from the agricultural population during the late war. General Debeney's reflections on this subject are worthy of study.

The financial and economic recovery of Germany is due in a great measure to the energetic action of General von Seekt, Chief of the Reichswehr, which should be closely examined. His aim is to support his new army formations by restored economy and healthy finances, while in the *Reichsministerium* he is preparing for the mobilization of the whole German nation, a tradition which General von Falkenhayn bequeathed to his successors.

(*May*, 1924.)—*Infantry in Trench Warfare.* By Commandant Padovani.—This article is divided into three parts, Part I dealing with

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the defence, and sub-divided into (1) organization of the ground, (2) normal life in the sector, (3) the enemy's attack, (4) outline of regimental defence orders. Part II deals with the offensive, and is subdivided into (1) characteristics of the attack on a fortified position, (2) preparation of the ground (to facilitate launching and maintaining the attack), (3) preparation of the troops, (4) dispositions for the attack, (5) attack orders. Part III is devoted to the actual execution of the attack.

*The Peninsular War.* The article by Commandant Grasset is continued.—The Spanish rising now spread to Saragossa. Marshal Bessiéres, who was commanding the French troops in the North of Spain, was aware of all these movements and took what steps he considered best to counteract them, reporting at the same time to the Emperor, who was at Bayonne engaged in drawing up a new constitution for Spain. But Napoleon, who allowed little initiative even to his marshals, sent his own orders based on reports three or four days old and constantly changing. Bessières was forced to disobey these, and thenceforth Napoleon, recognizing the necessity, contented himself with issuing general instructions, leaving to his lieutenants on the spot the responsibility for deciding on the best means for achieving the ends he had in view. (*To be continued.*)

*Our North African Races in the New Army.* The conclusion of the article by Lieut.-Colonel Clément Grandcourt, dealing with the question of *cadres*—officers and N.C.O.'s—both European and native, bringing out the difficulties experienced at the present day in obtaining them satisfactorily, investigating the reasons for this, and suggesting remedies. The necessity for enlisting into the ranks of the native army a certain number of European privates is regretted. It is objectionable to place privates of the ruling race under native N.C.O.'s, and the writer would retain only the number required for special services which cannot be, or ought not to be, entrusted to natives. In fine, the problem of the native army is infinitely more delicate and complex than is generally realized, and must be approached with prudence and caution.

*Military Chronicle of Economic Questions.* By Pierre Bruneau.—This month the high cost of living is referred to. Attempts to reduce prices in the army were made by introducing the *Société Coopérative Militaire*, but some of the advantages enjoyed by this establishment have had to be withdrawn in view of the complaints of private traders. The Society, however, works well in the occupied territories. In the Ruhr it has been necessary to forbid German merchants to demand higher prices from the Allies than from Germans, and in Mayence the G.O.C. has appointed a mixed commission to regulate prices.

*Books.* Amongst the books reviewed the following appears to be of general interest :—

*Mémoires du prince Louis Windischgraetz*, translated by Capt. Chomel de Jarnien. (Payot.)—The writer, who belongs to an old Hungarian family, held a high command at the front, was then Minister of Supplies, and later an Envoy Extraordinary. Admitted to all the political and fashionable circles of the Dual Monarchy, his quick intelligence, ardent temperament and energetic personality enabled him to exercise great

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influence on the tragic events of the last years of the Empire. His style is blunt, as that of one who has nothing to hide and nobody's feelings to consider. He criticizes Count Burian, and accuses the great General Staff of incapacity, while praising the excellence of the soldier, but in so doing discloses the virus of the pan-German Junker. He blames the General Staff for having sent an ultimatum to Serbia instead of promptly bombarding Belgrade, and, evidently a great admirer of the Germans, contrasts the disorder and slackness of the Austro-Hungarian staff with the method and order of the German. The book clearly reveals that which was wanting in the Empire of the Hapsburgs and prevented it from becoming a great nation. The Empire was not betrayed by blind fate, but met its death because it lacked unity and national discipline, and its officials patriotism and a sense of duty.

A. R. REYNOLDS.

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## *REVUE MILITAIRE SUISSE.*

(1924. *Nos.* 4 *to* 6 *inclusive.*)

COLONEL GROUARD'S article entitled *Le haut commandement et l'état-major* is continued and concluded in the numbers (4 to 6) of the *Revue* under notice. The importance of the subject under discussion is brought out in a striking manner in the article by Colonel Grouard, who is a fearless critic; he shows that, although the Great War was eventually won by the Entente Powers, there were occasions, and many of them, when victory was placed in dire jeopardy, owing to a failure on the part of politicians, and others, to apply the true principles of organization in connection with the arrangements in relation to the G.H.Q. and superior staff provided for the conduct of the war. Colonel Grouard gives in outline the principles upon which the staff of an independent Army should be organized; he also points out that it is the general in chief command who should personally dictate the plan of operations and that to the staff falls, in the first instance, the responsibility alone for collecting the information and data required by the general to enable him to sketch out his plan of campaign. After he has given his decision in relation to this plan, naturally, it is then the duty of the staff to take up the work of developing the same in detail, and of preparing and distributing the orders necessary to give effect to the general's intentions. These two functions are, however, not independent, and emphasis is laid by Colonel Grouard on the need for a Chief of Staff being completely familiar with the ideas of his general; indeed, the two should maintain the closest relations and should be at work incessantly elaborating the details of the plan of campaign. Dealing with the subject of command, Colonel Grouard thinks that normally an army should contain not more than four corps, together with one cavalry division, or even two such divisions, and the necessary army troops. In the case of a force of larger dimensions than here stated, a sub-division into armies, and maybe larger formations, becomes necessary; it may even become desirable to create separate and independent commands. Where the force is so large and the theatre of operations so extensive as to require an organization consisting

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of groups of armies, the principle to be employed in constituting the several groups is that each group shall be self-contained and so composed that a distinctive task or mission can be assigned to it; standardization in the composition of armies and groups of armies is neither desirable nor possible from a practical standpoint. Discussing the position which should be assigned to a Chief of Staff, Colonel Grouard suggests that there should be at G.H.Q. an officer of high rank and recognized ability in the position of *un véritable commandant-en-second;* he could appropriately bear the distinctive title of *major-général* and under him there should be a *chef d'état du major-général,* as was the case in Napoleon's time. In 1914 there was a *major-général* in France, but he was not vested with sufficient authority; his activities were limited to the direction of the operations of the French "Armée du Nord-Est." Colonel Grouard further rightly objects to the arrangement under which one general-in-chief has sometimes been called upon, in the capacity of a representative of the Minister, to *control* another general in chief command. Where an officer is supposed to be possessed of such outstanding abilities as to justify very large responsibilities being placed on his shoulders, he should, it is urged by Colonel Grouard, be given the *military command* over the other generals whose operations are to be supervised by him.

Having sketched out the principles upon which a G.H.Q. should be organized, Colonel Grouard next examines how matters would have worked in France had these principles been properly applied during the early stages of the Great War. He recognizes that the mobilization and the concentration of the French Army were carried out in a perfect manner, but he has some hard things to say of the operations constituting the opening phases of the Great War: the offensive in Alsace was, he thinks, *une absurdité;* the offensive in Lorraine, *sans être aussi complètement inepte, était des plus dangereuses;* other criticisms are also made. Colonel Grouard gives his views as to the manner in which the French Armies should have been employed on the outbreak of war: the First and Second Armies, which were to operate in the Vosges, should have both been placed under the direction of one of the generals commanding and, indeed, in order that the operations in the Eastern frontier should be properly co-ordinated, a commander-in-chief should have been designated with a view to exercising command over all the troops which might have to operate on the line Belfort–Toul. The Third and Fifth Armies should similarly have been combined under a single general for operations on the line Verdun–Mézières, whilst the Fourth Army should provisionally have been held under the direct orders of the G.Q.G. Colonel Grouard attributes the early successes of the Germans in 1914 mainly to the faulty organization in the command of the French Army when hostilities broke out. The want of co-ordination which is apparent in the operations of the Entente Armies in the initial phases of the war he traces to this cause, and to it he also ascribes the creation of the situation of which advantage was taken by the Germans, who were able, in consequence, to take up and hold a position at Rheims and also to seize St. Mihiel, positions which they retained up to the time of the final advance in 1918.

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Dealing with the staff, it is suggested by Colonel Grouard that a G.H.Q. staff should be constituted in two sections, one mobile and the other stationary; with such an arrangement, the mobile section could, without any dislocation of the work, conveniently accompany a commander-in-chief to the battle area. Colonel Grouard touches upon the general situation in 1915, and refers to the opposition raised, at the G.Q.G. at Chantilly, to the dispatch of an army to the Balkans; he thinks that the views held at Chantilly were too narrow and, in the particular circumstances, the staff at G.Q.G. was not in a position to form unbiased opinions and therefore was not in a position properly to grasp the essentials of the problems confronting the Entente Powers; nor could it be expected, placed as it was, to formulate a general *military policy* on sound lines. The opposition of G.Q.G. to the dispatch of an army as reinforcements in support of the Serbians led to the loss of much valuable time; and, finally, when the decision was taken—a decision which Colonel Grouard thinks was right—to adopt a course of which G.Q.G. did not approve, a serious mistake was made in placing the *Armée d'Orient* under the Generalissimo in France.

The constant friction of one kind and another which seems always to have been present in connection with the conduct of the war can be traced almost entirely to the circumstance that correct principles were continually being ignored in the arrangements made in relation to *le haut commandement et l'état-major.* The changes which took place at the French Ministry of War and in the chief command of the French Army are duly recorded by Colonel Grouard, who comments on the causes that led thereto. Commenting upon the supersession of General Joffre, whose period of command extended over the first 2½ years of the war, the Colonel calls attention to the fact that, in the first instance, the former had five French Armies directly under his own immediate command—it was during 1915 that the three groups of armies, the North, Centre and East, were formed—and expresses his disapproval of the arrangement, which, he considers, was extremely harmful, as the Generalissimo was thus prevented from concentrating his attention on those sections of the front which, from time to time, became of most importance. However, this arrangement was not, Colonel Grouard thinks, the principal cause of the early defeats of the Entente Armies, whose misfortunes he attributes almost entirely to the radical defects in the original plan of campaign and in the obscurity existing at G.Q.G. as to the true situation, factors which prevented the general-in-chief modifying the initial dispositions in time to place the Entente Armies in an advantageous position for meeting the German onslaught. After the removal of General Joffre, General Nivelle became Generalissimo, but did not possess the necessary qualities required for the post. The French War Minister, it is alleged, now began to interfere mischievously in the conduct of the war; had he been a military genius, the consequences might not have been serious. However, according to Colonel Grouard: " Ce qui s'est passé prouve que l'on n'avait pas d'idées nettes sur l'organisation rationelle, et cela tient à ce qu'on ne savait pas distinguer la stratégie de la politique militaire: la confusion dans les

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questions de principe entraîne forcément celles des procédés employés dans l'application."

General Nivelle's tenure of command lasted barely five months; he made way for General Pétain, whose first task was that of re-establishing order and discipline in the French Army. The choice of General Pétain for the position of Generalissimo proved a fortunate one; his great knowledge of the temperament of the French soldier, coupled with his firmness and tact, enabled him to restore discipline and thus to lay the foundations of future success. Of him, Colonel Grouard says, "il a été le véritable organisateur de la victoire."

The Caporetto disaster in October, 1917, created an extremely serious situation and resulted in both the French and the British Governments sending troops to Italy to stem the tide of the Austro-German invasion there. At the same time, a conference was held in London with a view to the better co-ordination of the operations of the Entente Armies. At this conference was sown the seed which eventually brought into existence the unification of command, under General Foch, of the troops in the western theatre of operations. However, the seed did not germinate immediately; withering breezes blew over it both from the Palace at Westminster and the British G.H.Q. in France. The German offensive in Picardy, launched on March 21st, 1918, was necessary to create the atmosphere in which the seed could take root and bear fruit. A conference was now held at Doullens, and on April 14th, 1918, it was announced that the British and French Governments had agreed to give General Foch the title of "Commandant-en-chef des Armées alliées," his command being confined to the troops operating in France. On the following day the Belgian king announced his adhesion to this arrangement and placed his army also under the orders of General Foch. Two days later the American President adopted a similar course. The story of the Great War, after the unity of command was established, is one of unbroken success.

In conclusion, Colonel Grouard expresses the opinion that for the conduct of a big war it is necessary to place the *general control* of the situation in the hands of a committee charged with the formulation of a military policy; the function of the committee should be that of allotting the necessary forces to each of the several theatres of operations and of defining the particular task assigned to each of the several armies. The province of military policy must not be confused with that of strategy; questions of military policy having been decided, one enters on what lies in the domain of strategy, the rôle of which is concerned with the handling of armies in order to bring about a battle or a series of battles. Whereas the problems of military policy require for their solution the joint knowledge of the politician and the soldier; on the other hand, strategy is exclusively the concern of the soldier. This does not mean, of course, that statesmen should not familiarize themselves with the problems and principles of strategy; indeed, it is desirable that they should do so, in the same way that soldiers aspiring to high command should make a study of political questions for a better understanding of their responsibilities.

M. Jean Fleurier's article, entitled *Une légende. La faillite de la*

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*fortification permanente pendant la grande guerre*, is continued (No. 5), the defence of Namur being dealt with in this part. Although the lessons to be derived from the defence of Namur are not so instructive as those provided by that of Liége, nevertheless there are two points which merit particular attention : (1) the short duration of the resistance put up by the Belgians at the former, and (2) the relatively small damage done to the Namur forts by the German artillery. The time gained by the hold-up of the invaders at Liége was profitably utilized by the Governor of Namur, who arranged for defence works to be constructed in the intervals between the detached forts ; the possibility of Namur being carried by a *coup de main* was therefore guarded against. The course of events caused attention to be turned to the idea of *fortification en profondeur*, but it was not fully developed at Namur ; an exterior system of defences was not provided beyond the line of detached forts, and infantry was not pushed out beyond the permanent defences with a view to hindering the bombardment of the forts, as was done, for instance, at Belfort. The second line of defences thrown up at Namur was practically concentric with the first line and no attempt was made to construct retrenchments on the " chord " of the front attacked. The number of troops in Namur were fewer than those in Liêge ; the garrison of the former consisted of the 4th Division (say, 13,000 men) and 10,000 fortress troops. On the other hand, the French Army under General Lanrezac was within supporting distance of Namur and, indeed, had a *liaison* officer in the Belgian fortress. The garrison of Namur was increased by the addition of some of the troops who escaped from Liége ; unfortunately, they told pessimistic tales and on that account did not prove to be altogether a source of strength. On the material side, so far as the defence works were concerned, Namur was in a better condition than Liége to stand a siege, but the morale of the defenders proved disappointing ; moreover, there was a marked difference in the personalities of the two Governors, and this also influenced the two situations differently from the standpoint of staying power. In view of their experiences at Liége, the Germans approached Namur with great caution and made no attempt to take the place by a *coup de main*, but relied entirely on their heavy artillery, which was given full opportunity for making its weight felt : it was here that birth was given to the now celebrated phrase, " The artillery conquers ; infantry merely occupies." The advanced Belgian troops began to retire within the shelter of the Namur defences on August 20th ; the German bombardment opened on the following day and at 4 p.m. on the 23rd the order for the retreat was given by the Governor of Namur. It has to be remembered that at the date on which the Germans commenced their attack on Namur, the fortress was already practically isolated ; the Belgian Field Army had then retired towards Antwerp from the Gette ; the French Fifth Army was on the Sambre, in the neighbourhood of Charleroi, some 13 km. from the western forts of Namur. Further, the German First Army had already entered Brussels, thus interposing itself between Namur and the remainder of Belgium. A table is furnished in the original article in which are set out the dates on which the bombardment of the several forts began, those on which they surrendered, and, in

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some cases, the losses suffered. In conclusion, M. Fleurier expresses the opinion that Namur fulfilled its mission up to August 23rd; however, the surrender of the place was premature and thereby German troops, which should have been held fast at the Belgian fortress, were released for operations against Maubeuge, where they arrived on August 27th. The total casualties suffered by the Germans at Namur did not exceed 1,000 all ranks (about a third of these were killed). The Belgian artillery proved itself very inferior to the German artillery and was at once dominated by the latter. The fall of Namur was of considerable value to the Germans for propaganda purposes, and helped to create the legend as to the immensely destructive power of the German "super-cannon." Whereas the defence of Liége had had the effect of raising the morale of the Belgians, that of Namur, unfortunately, had that of distinctly lowering it.

W.A.J.O'M.

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*BULLETIN BELGE DES SCIENCES MILITAIRES.*

(1924. Nos. 4 to 6 inclusive.)

THE account of the operations of the Belgian Army in connection with the defence of Antwerp is continued in Numbers 4 to 6 of the *Bulletin* under notice. The general situation in the sub-sector of the 5th Division as it existed in the afternoon of October 5th is outlined. Fortunately, the German infantry, which had gained a footing on the north bank of the Nethe, west of Lierre, did not show much enterprise. Had the Belgians had fresh troops and sufficient artillery, it is probable the enemy's position north of the river would soon have been rendered untenable. During the evening of October 5th the Belgians began preparations for a counter-attack for the purpose of driving the enemy from the north bank of the river. One of the chief difficulties of the Belgians at this time arose from the fact that, even during the daytime, the support given to the infantry by the artillery was of the feeblest kind, whereas at night, owing to the fact that the necessary equipment had not been provided and also to the circumstance that the gunners had not been trained for the purpose, the Belgian artillery could not come into action at all, once the light failed.

At 6.35 p.m. on the 5th, a report was received at Fortress Headquarters in Antwerp conveying information as to the movements of the enemy which had been obtained by an airman during a reconnaissance; *inter alia*, it was stated that the enemy had placed in position the bays of a temporary bridge at a point on the river 1,000 m. south-west of the steeple in Lierre. This information was passed on to the armoured-train and to the commander of Fort Broechem, and at 7.40 p.m. it was also communicated to General Paris, in order that his artillery might make an attempt to destroy the German bridge. However, it was already becoming dusk and it was felt that the guns could do no effective work; in consequence, no action was taken on the R.N.D. front.

A good deal of uncertainty seems still to have existed at Fortress Headquarters as to the dispositions of the troops in the 5th Division sub-sector. Certain enquiries on the subject were answered, but the

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information given was not altogether correct. Some misunderstanding appears also to have existed at General Paris's headquarters as to which units of Belgian troops had been placed under the British General's orders, and as to the positions occupied by them; this led to some unnecessary correspondence.

It was proposed to launch the counter-attack being prepared in the 5th Division sub-sector at 2 a.m. on the 6th; it was decided that, when the troops moved forward, a detachment of Engineers should make an attempt to destroy the temporary bridge south-west of Lierre. General Coveliers was placed in command of the troops detailed for the counter-attack. At the same time, General Paris was directed to hold his troops in readiness to join in the counter-attack; he was informed that, should it become necessary for his troops to participate, orders would be given him by Divisional Headquarters. It was now arranged that the Brigade and Regimental Commanders, whose troops were to take part in the counter-attack, should meet at the battle headquarters of the 17th Brigade, then east of Linth, in order to work out the details of the attack. At the hour fixed for the conference, the three Brigade Commanders concerned had arrived at the rendezvous, but all the Regimental Commanders had not put in an appearance; up to 9.30 p.m. no decision had been arrived at by those present—the three Brigade Commanders were still seeking information as to the dispositions of the troops under their respective commands. At this time, units were in many cases intermixed; in other cases, detachments had become completely isolated, and, generally speaking, the troops seem to have lost their nerve and the least bit of firing at once produced a panic. About the hour last named, a Staff Officer of the 5th Division present at the rendezvous reported to his headquarters that the Brigade Commanders had come to the conclusion that a counter-attack could not, in the existing circumstances, be carried out; however, should express orders be issued to them on the subject they would act according to their tenor. Three of the Regimental Commanders were still absent and the efforts made to get in touch with them had failed. A Staff Officer now volunteered to go in search of the Commander of the 2nd Carabiniers, who was in the neighbourhood of Lachenen. Leaving the 17th Brigade Headquarters in a motor-car, with headlights turned full on, he succeeded in his mission and took the missing Colonel back with him. Incidentally, it may be stated that the passage of the brightly-lit car had a most reassuring effect on the troops: all the dispatch-riders who had been sent with messages for the missing Regimental Commanders had turned back as they had been fired upon, and the idea had got about that the enemy had penetrated into the cover of the woods at Looverjik; this assumption was now proved to be erroneous. Eventually all the Regimental Commanders concerned arrived at the rendezvous and it was possible to draw up an appreciation of the situation, a copy of which (text given in the original article) was dispatched to Divisional Headquarters at 10.10 p.m.; it was, however, not received at Bouchout until 11.30 p.m. After the dispatch of the appreciation of the situation, the officers at the battle headquarters, east of Linth, continued to concert measures for the counter-attack and by midnight a plan had been agreed

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upon; the necessary orders were then drawn up. The Divisional Commander was duly informed as to the final decision arrived at by the three Brigade Commanders and was furnished with an outline of the scheme of attack worked out; this did not reach him until 1.20 a.m. on the 6th. The Divisional Commander, however, on the receipt of the "appreciation," had decided that a counter-attack must be made, and at 12.30 a.m. had sent a peremptory order to this effect to General Coveliers, directing him to attack on the line Ringenhof–Ander Stad—the latter was to remain in touch on his left with General Paris. At the hour last named, orders were also sent to General Paris directing him to join in the attack; he was to make a special effort to destroy the German bridge south-west of Lierre. At 2.5 a.m., on the receipt of the foregoing orders, General Paris sent a dispatch to Divisional Headquarquarters at Bouchout stating that the orders had reached him at too late an hour to enable him to take any action thereon. He added that he could do no more with the troops under his command than hold the trenches occupied by them, and that an independent force was necessary for the purpose of carrying out the counter-attack ordered. The inaction of General Paris, and, indeed, his conduct generally in relation to the operations, is much criticized by the author of the original article.

The dispositions for the counter-attack are given in the original article and the operations which ensued are described. During the attack, which was carried out in the dark, a ruse was adopted by the enemy on the part of the front where Colonel Tiechon (2nd Chasseurs) was in command; as if to warn the Belgians that the British troops had already reached the locality, German soldiers shouted "English! English!" Colonel Tiechon was entirely deceived by these shouts and moved forward to a brick-oven near him; as he turned the corner he was felled to the ground by three German soldiers who took him prisoner. The Belgian counter-attack was delivered with energy; however, after a temporary success in places it failed all along the line. This failure naturally increased the disorder already existing in the ranks of the Belgian troops.

In the meantime, orders had also been given to the Belgian 3rd and 6th Divisions, then operating in the 4th sector of Antwerp, to act on the offensive on their fronts in order to attract the enemy's attention to the westward of the Willebroeck Canal with a view to facilitating the operations of the 5th Division. At this time, the forts at Breendonck, Liezele and Bornhem and the redoubts at Letterheide and Puers were still intact. The Belgian offensive movement was met by a counter-attack delivered by the German troops at Larendries and St. Amand, and the Belgians had eventually to give ground in the 4th sector.

The first parts of an article entitled *L'Enveloppement à la guerre*, by Lieut.-General Baron W. de Heusch, appear in Numbers 5 and 6 of the *Bulletin* under notice; the object of the Baron is to restate the true doctrine of war. He points out that the far-reaching changes which have taken place in recent times in the equipment of armies necessitate a reconsideration of the deductions drawn from historical material so far as they relate to tactical methods. The great distance

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apart at which opposing forces come into contact on the battlefield is to-day, and, indeed, has been since 1870, a factor which has tended to transfer to the domain of strategy problems which formerly were considered properly to belong to the domain of tactics. Baron de Heusch feels that the full bearing of recent developments in the military art has not been clearly appreciated in dealing with strategical problems. He thinks that the Germans have confused ideas on the subject; not content with having produced von Clausewitz, they seem to see in their General von Schlieffen the inventor of a strategy superior to all others and throwing that of Napoleon completely into the shade, a strategy based on Hannibal's tactical manœuvre in the Battle of Cannæ, where the Carthaginian general enveloped both wings of the army led by the Roman Consul Varon. The Battle of Cannæ would be looked upon to-day as an incident of minor importance, an encounter in the nature of an engagement on a divisional front. Hannibal's enveloping movement was made against an inert unmanageable mass holding a relatively narrow front; on the other hand, the enveloping movement attempted by the Germans in 1914 in the initial phase of the Great War was directed against forces which were supple and extremely mobile, and which, moreover, were operating on a very widely extended front; they were, in consequence, in a position to carry out suitable manœuvres with a view to avoiding battle in a situation which might prove disadvantageous to them. Envelopment tactics derive their value almost entirely from the element of surprise, where it can be secured; more than anything else, it is surprise that has the tendency to destroy the morale of an army upon which an unexpected blow falls with suddenness and swiftness. But in these days, when the fronts of opposing forces stretch over a line of immense length, it is difficult to secure telling moral effects on a scale sufficiently large to be of military value; it takes, in these circumstances, a considerable time for combatants fighting on one section of a front to learn what is happening, or has happened, on another section of the front, literally thousands of yards away. For instance, it was quite late at night that even the King of Prussia and his staff learnt of the successful envelopment of the French right on the northern part of the battlefield of St. Privat (August 18th, 1870). Baron de Heusch suggests that it was not necessary for von Schlieffen to have discovered the outstanding merits of Hannibal's tactics at Cannæ in order to employ the talent of his German brain for the purpose of inventing a distinctive German strategy; there is no reason why he should not, with an equal probability of success, have based his invention on the tactics employed by Hannibal at the Battle of the Trebbia, where by other processes, such as the adoption of a ruse and the employment of light troops against the flanks of the Romans, he also managed to secure a complete victory. In the military art, history, Baron de Heusch points out, plays the important part of a great preceptor, and to it the military student must always turn when he seeks to confirm the correctness, or otherwise, of a theory which he desires to apply in practice. As an aid to the study of the problem of envelopment tactics, Baron de Heusch has, in his article, set out in outline the principal battles of the Napoleonic and succeeding periods: therein is

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shown the extent to which successes on the battlefield can be attributed to the employment of envelopment tactics.

Among other subjects dealt with in the numbers of the *Bulletin* under notice there is an account of the Russian invasion of Germany and Austria in 1914—it appears in the final part of Major Jobe's article entitled *Le principe de la bataille* (No. 4); the facts are clearly stated and the strategy of the Great War is briefly discussed. The first part of an article entitled *Le terrain et la guerre* is contained in No. 6 of the series; in it Major B. E. M. De Grox examines the question as to whether geographical considerations had any influence on the plan of operations of the Great War, 1914–18, and particularly so in the initial phase thereof.

W.A.J.O'M.

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*MILITÄR WOCHENBLATT.*

*25th October*, 1923.—The leading article in this number is a review by General v. Kuhl of the ninth volume of the French General Palat's book on the war on the west front. The volume deals with the offensives of 1915.

After some half a column devoted to belittling the value of General Palat as a military historian and to ridiculing the sources from which his information is said to have been drawn, the critic proceeds to say that they should not be deterred from study of French military literature, which is "instructive in many respects and helps to correct judgment of our own operations." These often proved much more effective than hitherto they were inclined to believe. Palat shows that the French soldier was in no way better prepared for position warfare than the German. Also the munitions crisis in the German army does not seem to have been so threatening as in France. At what date this was the critic does not explain, but he proceeds with the extraordinary sentence: "If the Germans had known their opponent's situation in the autumn of 1914 and had undertaken just such a powerful offensive as at Verdun in 1916, but against a more suitable section than the Yser, then the French supplies of munitions would not have sufficed for an uninterrupted fight." The argument is typical.

The critic then deals at some length with the optimism of General Joffre in the winter of 1914–15, who is said to have scouted the idea of a second winter of war, for the Germans would be utterly worn out by the end of 1915. This serves the critic as an answer to those who reproach German G.H.Q. for their offensive in 1918. "War is inevitably waged in the element of uncertainty."

After a digression on the struggle between the conduct of the war by the military leaders and politics, the critic deals with certain of the battles of 1915. Palat is said to make some "interesting statements" concerning the gas attack by the 4th German Army at Ypres on 22nd April, 1915. "Already, by the beginning of 1915, it was learnt in France that the Germans were busying themselves with making a war gas." Von Kuhl then gives the full name, regiment, etc., of the German prisoner who, on the night of the 13th–14th April, made accurate

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statements about the gas cylinders, about the method planned for loosing off the gas and about the point of attack, yet the information was not sufficiently appreciated by either the French or British headquarters. So the German attack on the 22nd came as a surprise. According to Palat it could have been pushed as far as Dunkirk without resistance, if only German reserves had been ready at hand. Von Kuhl remarks that the situation recalls the events on 20th November, 1917, at Cambrai, where, too, a new weapon (tanks appearing for the first time in mass), secured an unexpected success for the English, who were not in a position to exploit it.

The German attack at Ypres upset and delayed the preparations for the great allied spring attack in Artois. The May attack by La Bassée and Arras again aimed at the break-through. After initial successes the worn-out French had to postpone the costly attack to the middle of June. The Cavalry Corps, which was to have exploited the success, was withdrawn, without effecting its object, behind the front once more. " Even the Corps Cavalry had found no opportunity of carrying out the instruction of the Army leader, General D'Urbal, which ran : ' It is a case of attacking at full gallop. The time of cavalry on foot is past.' " With the action of the British in the battle Palat is said to be but little satisfied. " French gave up the attack too soon, discouraged too quickly, as he generally was."

Von Kuhl then turns to the " renewed great attack by the British and French in Artois and by the French in Champagne " which began on 25th September, 1915. The secret of the forthcoming attack was badly guarded, the plan was soon in everybody's mouth. The effort to make the Germans think the attack was intended to be made in Alsace-Lorraine under General Dubail was futile. This time such a thorough artillery preparation was to precede the assault that it must succeed ; but the hopes were not fulfilled. Palat admits that the offensive failed and that the small results gained were out of all proportion to the great losses sustained.

Palat concludes his observations by saying that " the year 1915 was the year of the great disillusionments. The first was the feeble conduct of the war by the Italians, from whose participation hopes of an early finish had sprung. The Dardanelles undertaking had failed. With difficulty were the British induced by the French not to withdraw their troops from Salonika. The experiences in the western theatre of war had shown that the enemy's successive positions could not be broken through at one go with the means then available. The heavy artillery and ammunition supply were not yet adequate. No one knew which method of attack should be used in future for the break-through. Was it better to attack on a broad front after long preparation, or was success to be won by a series of heavy successive assaults, leading to the using up of the hostile reserves ? "

As Palat shows, the prospects of the German Higher Command for 1916 were thoroughly favourable in the West. But they had not freed their back for a great offensive in the West, in spite of brilliant successes in the East. " The attack at Verdun in February, 1916, had only a limited objective. That it failed was of extraordinary significance for

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the further conduct of the war. From all French contemporaneous and subsequent reports it is evident that the successful defence of Verdun raised the lowered self-confidence of the French Army and nation in a way never dreamt of."

*10th December*, 1923.—The value and virtue of private study form the subject of the leading article in this number. The writer begins by bewailing the fact that the Treaty of Versailles has abolished all the institutions at which the officers were prepared for the highest tasks of their profession. "The academies belong to past history." Their loss is deplored as they gave the officers—teachers and students—the time for systematic study. The training which they gave could, to be sure, only stimulate. The writer then gives an extract from General v. Freytag-Loringhoven's book of reminiscences to show that, as far as he possibly could, he tried to encourage officers to study, though without any striking success. In the Prussian Army, especially, training was directed exclusively to action, which, after all, is unquestionably more important than thought in the military sphere. Count Schlieffen is then quoted to show that their duties were so exacting and onerous that officers actually had no time for study. The writer then warns his readers of the danger, particularly at a military institution, of the students accepting, without criticism, everything that is given them. Another danger to which attention is drawn is dissipation of effort; the man who does not fix definite limits will wander easily from flower to flower and lose the much by pursuing the many. This does not mean, the writer continues, that the officer should confine himself to military studies alone, but unless he limits himself he will gain but superficial knowledge. This, then, leads to a quotation from a book written in 1820 by a Prussian officer of a eulogy of Scharnhorst, and a final exhortation to industry.

Other articles in this number include a review of the military political situation of Great Britain, with the usual complaint that we do not appreciate the danger to us of France's military hegemony; the American share in gas warfare; a bitter criticism of the exposures made by Count Robert Zedlitz-Trutzschler, former Court Chamberlain to the ex-Kaiser, a book which should make rather entertaining reading; and a review of an official brochure on the question of the responsibility for the war.

E.G.W.

*MILITÄRWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.*

*Numbers for March–April, and May–June*, 1924.

IN the January–February number appeared the first part of a discussion on the supreme command of the Allied Armies of 1813. In the two numbers under review the discussion is continued and ended. Schwarzenburg's troubles, political rather than strategical, are interestingly described and the student of history will find each statement referred to the appropriate authority. The life of a staff officer of those days must have been a thankless one.

Two articles under review deal with the operations which resulted in the first siege of Przemysl in September, 1914. Previous articles on

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these operations were given in 1918: "The Defence of Przemysl, 1914–15" (G. M. Schwall) and "The Strategical Part Played by Przemysl on the Eastern Front" (by Major Stuckheil, 1923).

The first of the present articles—by Colonel Rudolf Fleischer (Inf. Regt. 6) begins in the January–February number with his promotion to the command of a battalion of 800 strong, formed from the remains of the three regimental battalions. His adventures on the retreat in which he loses half his battalion and finds them again, circles round Przemysl, where he sees German airmen, crosses the San, and, in a forced march, loses for good 25 per cent. of his strength, are graphically told. The retreat has made him determined, in any future reincarnation, to choose some other branch of the service.

The other article, by Major Stuckheil, describes the provisioning and preparing for defence of the fortress itself, whilst he records his impressions of the retreat of the 3rd Army to which Colonel Fleischer belonged.

The diaries and reports compiled during the defence were either lost in a balloon which was sent up from Przemysl in March, 1915, or were otherwise destroyed, and Major Stuckheil is careful not to claim entire accuracy for his account.

Przemysl lay, on mobilization, in the X Corps area and formed an area command, "Subrayon Przemysl." Five battalions, 1 cavalry patrol (?), 1 battery, Field Artillery, a fortress artillery regiment, and several companies Engineers composed the garrison of the moment.

The construction of additional strong points, intermediate works, obstacles, etc., etc., began at once, but it was not till the 20th day of mobilization that the Engineer staff was complete at the formidable figure of 300 officers, 2,200 tradesmen, 27,000 labour troops and 900 wagons of sorts.

A point strongly emphasized is the difficulties which resulted from the presence of the staff of higher commands in the fortress and the constant passage of troops and material to the front. *Contre-espionage* absorbed much time and attention.

The provisioning of the fortress went on uninterruptedly until the last moment, but the garrison was increased to 131,000 men and 21,000 horses, as against the pre-arranged figure of 85,000 men and 3,700 horses, and in consequence there were only 80 days' rations (or so) for men and about 70 for horses in the fortress when it was invested.

From the 12th to the 16th of September the crossings of the San at Przemysl were the scene of considerable confusion during the retreat of the 3rd Army. On the 16th Przemysl was informed that it was left to its own devices and was to hold out to the last, but it was not till the evening of the 18th that the field army was finally clear of the fortress area.

On the 19th, bridges and railway communication with the outside world were blown up and on the 23rd the investment was practically complete.

Good diagrams illustrate the articles and give the arrangements for defence and the strength of various arms at various dates.

Major Dr. Renduliç continues a study of the infantry tactics of the

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training manuals of European Armies. The comparison is interesting and gives an impression of general similarity of method, although minor variations are noticed.

The short account of the activities of German tanks in the war is finished. The historical part is not interesting. The main lesson drawn is the futility of employing tanks in marshy soil, after too long an approach march or against the technical judgment of the tank commander. Thus in the attack on Fort Pompelle, near Rheims, 15 tanks were employed in spite of an unfavourable report, and 10 were lost. Tanks in the counter-attack at Cambrai on the 11th of October, 1918, are credited with particularly useful work, whereas at Bapaume at the end of September three German tanks, the survivors of two sections (5 each), after an exhausting and unreconnoitred approach march, reached the appointed place only to be put out of action at once by the German artillery, which had not been warned of their advent.

Dipl. Ing. Fritz Heigl does not approve of the German word *tarnung*. He declares his preference for " camouflage," and divides it into :—

POLITICAL AND STRATEGICAL.

1. Spreading false or misleading information and camouflaging one's own messages.
2. Pseudonyms ; as, for example, the word " tanks."
3. Concealment of concentration and approach marches.

TACTICAL.

4. Smoke.
5. Camouflage against sound-ranging.
6. Camouflage of individual guns, tanks, ships, etc.
7. Camouflage of defensive works and of roads.

Under heading (1) the palm is offered to the Allies. A German N.C.O. prisoner is quoted as having lulled the French into false security before the German attack of May, 1918. A similar incident preceding the Canadian attack on the Vimy Ridge might have been quoted. The name " tank " is considered to have served a great purpose and the attention called to the French heavy tank by its name " Char de la Seyne " is contrasted with the indifference with which a name such as " Char 2 C " would have evoked.

The " passive " concealment of concentration quoted as the masterpiece is that before the German offensive of May, 1918 ; whilst, as an " active " concealment, Solomon's book, *Strategic Camouflage*, is quoted as evidence of successful German camouflage of whole divisions. The author feels, himself, a little doubtful, for he adds that, whether this wholesale camouflage of formations be true or not, it points the finger to the camouflage of the future.

Considerable space is devoted to camouflage against sound-ranging. The author is correct in saying that it is more or less impossible, except by such a volume of noise as accompanied an opening offensive on the Western front.

He advocates, and it would seem rightly, the placing of isolated guns or sections, for emergency, or normal, support and counter-battery

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work, while the remainder are held in reserve for the *pièce de résistance*, and shifted immediately afterwards. Dummy flashes are considered useful camouflage against flash-spotters. In my experience they were of little avail.

Two outstanding items of tactical camouflage are quoted. The camouflage of Montdidier Viaduct (as a group of lofty elms) by the French, and of a monument near St. Quentin as an observation post by ourselves.

In the May–June number there are, in addition to those recorded, articles on heavy gun and heavy load traction by four-wheel drive motor-carriages, and on the relative fighting strengths in aircraft in the world of to-day.

H.St.J.L.W.

## *HEERESTECHNIK.*

### (*May, June and July Numbers.*)

Dr. Ing. Becker concludes his description of the ballistograph. His experiments have shown that, although generally less precise than the Boulengé, the difference is very small and the comparatively insignificant weight makes it much more suitable for calibration on service. The instrument does not depend upon any direct action of projectile or shell-wave, whereas most methods do ; and it can be used for any elevation. If heavier construction is allowed the ballistograph might certainly equal the Boulengé in precision and be equally valuable at artillery schools. Such matters as the rotation of the head of the shell round the line of flight, at any point in the trajectory, the effect of increase of elevation on the muzzle velocity, the angle of impact, etc., can all be photographically recorded, whilst by using two or more ballistographs each round of a series may be recorded at the beginning and end of its flight.

It is thought that the timing apparatus employed may have value for sound-ranging.

Captain von Giesecke describes the German G.S. limbered waggon 95, with its wheel-base of 1,460 mm. This waggon gave considerable trouble during the later stages of the war. There is a lot of iron in the model (as there is bound to be in limbered waggons), and the article asks the question as to whether a limbered waggon is really worth while. On the whole, the conclusion is, No.

Any waggon should start by having the normal wheel-base for the countryside in question, otherwise it has to break its own path and often has one wheel in a rut and the other on higher and unbroken roadway. The limbered waggon is much better across country and turns quicker—but the normal country waggon is easier unloaded and loaded, is much easier transported by rail ($\frac{1}{5}$ of the space packed on trucks), costs half the price, may be secured in large numbers on mobilization, and returned to farm use on demobilization, and employs much less iron.

The Austrians had, before the war, evolved a good and fairly general type of country cart which was of great value in the war.

The German protractor, circular in shape but with pieces cut away

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parallel from opposite edges (in order to fit the pocket) is described. The outer edge is graduated in millièmes, and co-ordinate measures (for the grid) and scales are added. It is interestingly different from our own.

Lieut. Arnold writes of a method of training artillery observers in one or two line observation on a sand model. Ordinary service instruments are used, and although there is nothing either new or important in the procedure, the article would repay study for one confronted with indoor training. The minor points, such as the blowing of puffs of smoke through an india-rubber tube up through a hole in the sand to illustrate the smoke of discharge or of burst, are well worked out.

The annual report of the German National Survey is reviewed. The department is considerably reduced compared with its pre-war establishment, but has carried out new first and second order triangulations, levelling and surveys at 1/25,000. There are stereo-photogrammetric and air-photo sections. The trig. records published in some 30 volumes are continued, etc. Perhaps the matter of greatest interest is the new 1/5,000 (12 inches to the mile) cadastrals. A 12-sheet series of Berlin and the neighbourhood at 1/50,000 has been published.

Special maps for air navigation have been discussed but have not been published because of the expense involved.

An investigation of the behaviour of invar wires (24 metres long) from 1905 to 1921 showed an annual growth of a 1/1,000,000th part of the length. But in 1921–2 they showed a shortening of ten times as much, possibly owing to a sea voyage. These figures will be of peculiar interest to British surveyors.

Pigeons and their habits, and their powers and limitations are discussed in an article which might repay study.

Professor Dr. Brunswig's book *Explosivstoffe* is reviewed at great length. In fact, the review by Captain Justrow finds place in five consecutive parts ending in the July number, but book and reviews are too technical for any but the expert.

The *Regional Geology of the Theatres of War*, which has been threatened for some time, is appearing in 13 volumes. Volumes 4 and 5—*Before Verdun* and *Argonne and the Champagne* are already published. Volumes 7 and 8, which will deal with *Picardy, Artois and Hennegau* and *Flanders*, respectively, will be of interest to soldiers, as will also the volumes on Macedonia, and South-east Macedonia and Asia Minor.

Volume II of *Der Grosse Krieg*, 1914–1918, has appeared and is reviewed by Major-General A. D. von Barries.

The period is from the spring of 1915, to winter 1916–17, and includes Falkenhayn's régime. He himself was replaced in August, 1916, but his policy and his undertakings had, naturally, to be carried through for a period, and the volume ends at the time when the third supreme command (Hindenburg and Ludendorff) began to make itself felt. There are nine parts, ranging from the general political and military factors to the operations on the western, eastern, Serbian and Roumanian fronts. Lieut.-General Balk is responsible for the western front.

Major von Wallenberg (political part) states that the political leadership, strong in the Entente countries, in Germany did nothing but hinder,

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forbid and disturb. Differences of opinion between v. Falkenhayn and Hindenburg are alluded to, and although Falkenhayn's measures appear to be freely criticized, he is well spoken of on the whole.

The "official" part of the July number is entirely taken up with an article on "Wireless." Ten well-reproduced diagrams in colour illustrate the text.

The following books, amongst others, are briefly reviewed :—

*Coast Defence and Coast Fortification.* Major Klingbeil. See July number.

*The Sea War* (Der Krieg zur See, 1914–1918). Volume 4. See June number.

———————— H.St.J.L.W.

## *VOINA I MIR.*

(*No.* 10 *continued.*)

E. Dostovalov, in *Landing Operations and Coast Defence,* discusses, with special reference to Russia and its coast-line on the Black Sea, how a country without a fleet, or with a fleet inferior to its adversary's, can successfully defend its shores. He states that the object of a country so situated must be to prevent an army landing on its shores and advancing into the interior. Even a weak fleet can do much towards this end by delaying the preparation and execution of landing operations, gaining time for the strengthening of coast defences and for the concentration of troops. New methods of transport introduced during the world war, facilitating the movements of large masses of troops, have made an essential change in the relative chances of the invader and defender. The aim of this article is to appreciate the data now available. The writer first deals with the question of transport of troops, and shows the enormous scale on which such operations were carried out : *e.g.*, one French transport fleet carried 2,152,622 men between France and the colonies. He then discusses the general character of landing operations and states that, from the attack by the Athenians on Syracuse in 415 B.C. to the operations in Gallipoli in 1915, the success of such operations has depended more than other war operations on accidental happenings, in many cases unforeseeable, and on the exceptional skill and determination of the leaders. Before considering the methods by which modern landing operations should be carried out, the experiences of the late war must be considered from the point of view of the struggle between a fleet and coast artillery assisted by aircraft. Owing to the perfecting of means of observation, bombardment of coast defences can now be carried out at a range of 40,000 metres or more. Increase in mobility and manœuvring power has enabled vessels to concentrate quickly. Small vessels which afford a difficult target are suitable for the attack of ports and of boats lying in a roadstead. Monitors can be used for operations in shallow waters ; armed with one or two heavy guns, they are adapted for the bombardment of coast defences where the shallows would prevent the use of larger vessels. Artificial fog is a useful auxiliary in certain types of attack, such as forcing narrows, and in attacks on harbours. Aircraft was little used in engagements between the fleet and coast

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defences, but they will undoubtedly play a large part in the future. Without aviation coast defence is blind.

The writer describes in detail the attempt to force the Dardanelles by the allied fleets and considers that these operations have once more emphasized the ability of coast defences to successfully resist an attack by sea unsupported by landings. The bombardment of the batteries in the Dardanelles showed the wonderful tenacity of batteries with turret mountings and of batteries in covered positions, whilst the unsuitability of batteries in open positions was demonstrated.

The writer describes the measures taken by the Germans for the defence of the Flanders coast and the English methods of attack by means of artificial fog and monitors. Experience has shown the necessity of increasing the size of coast artillery up to calibres of 16 or even 18 inches. It has confirmed the advantages of concealed and covered positions for coast batteries. It has shown that immobile coast guns are not only essential in certain cases, but must be further perfected in accuracy and range ; heavy mobile artillery and a powerful air fleet will enable swift concentrations to be made at points on the coast where the fight between coast batteries and the fleet has already started. The part played by aviation on the Flanders coast is described and the writer gives his views as to the part aviation will play in the future. He considers it will not be possible for a country to undertake landing operations in the future unless it has command of the air as well as of the sea. A continuation of the article is to follow. In an appendix is given a list of the German naval guns with their ranges and distribution in groups which were used for the defence of the Flanders coast.

In this number of the magazine a section which comprises two articles is devoted to Aviation. The first article, "The Principles of Aerial Warfare," by V. Kolossovsky, treats of the subject of aerial fighting generally, and describes with illustrations the types of machines which would be used under varying circumstances. The second article, also illustrated, entitled "The Present Condition of Aerial Communication," by A. Shershevsky, describes the various type of passenger aeroplanes and dirigibles and their constructional requirements. He discusses the subject of aerial stations, the organization of an aerial route, the organization of meteorological stations and radio connections and, finally, the present development of the European aerial net and the future of aerial communication.

(No. 11.)

A well-illustrated article by Engineer Captain Hegel, entitled "Present Position of the Problem of Tanks," is of considerable interest. The author hopes that, by a study of the technical side of the question, conclusions may be arrived at as to the value and future significance of tanks. He divides tanks into three classes—light, weighing 3 to 10 tons ; medium, of 10 to 20 tons ; and heavy, of 20–60 tons. The German heavy tank weighed as much as 150 tons. Heavy tanks must be strongly armoured to withstand field artillery. Their task is to make a breach in fortified lines and open the road to infantry and light tanks. The task of medium and light tanks is the exploitation of success and

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the continuation of the attack. They must, therefore, possess great swiftness and renounce strong armament and protection. Under certain conditions such tanks must act in conjunction with cavalry, and it is possible they may partly replace that arm. Under cover of the heavy tanks will follow also special infantry tank tractors. These must be strongly protected but weakly armed and, like the British tank Mark IX, must be able to carry an infantry detachment of 50 men. Their object is to break through to the enemy rear and there to form centres of resistance. The division of swift light tanks into light and medium occurred during the war owing to the difference in the views of the English and French. Both countries constructed two splendid types of light tank, the Whippet A and the Renault, respectively. The English tank weighted 14 tons and was armed with three machine-guns, whilst the Renault weighed 6·5 tons and was armed with one machine-gun and one field-gun.

The swift tank must be as light as possible. Its outer dimensions are governed entirely by its armament. In the last war tanks could be armed with machine-guns only, because of the numerical inferiority of the German tanks, but in future such conditions will not obtain. A tank must be in a position to knock out an enemy tank, and this can only be done with the aid of guns. The Americans have armed their " Medium Tank " with a 6-pounder gun and one or two machine-guns. According to recent information, the French are trying to improve their Renault tank ; it will be heavier and hold a crew of three men. They have also a scheme for constructing an ultra-light tank for one man only, and provided with Kegress chains. Generally speaking, the French and Italian tanks can be divided into two types, very heavy and very light, whilst the English and Americans have something between the two. The Americans propose to develop from their medium tank their swift tank of the future, whilst the English are improving their " Medium Tank D " to the same end.

Owing to the smaller vulnerability of light tanks, as shown by experience in the war, the evolution of tank construction, so far as heavy tanks are concerned, has come to a standstill. Italy, apparently, is chiefly interested in light tanks, but she has several examples of a heavy tank of 42 tons, the " Fiat Typo 2000." Germany has actually constructed two tanks of 150 tons. The French tank " Char de Rupture," of 60 tons, was constructed towards the end of the war and is a fine example of heavy tank construction. The maximum thickness of its armour is 5 cm., it can cross a ditch 5 metres wide and pass through water 1·5 metres deep. In England the Mark V remains the latest form of heavy tank, as no new developments were made after the end of the war. The American army has about 100 examples of the Anglo-American tank Mark VIII. The author describes this tank in detail, as being a type of an up-to-date heavy tank, and gives photographs of it. It is armed with two 6-pounders and seven machine-guns and its weight is 37 tons. The author then discusses the question of caterpillars, the most important part of a tank. He describes, with the aid of diagrams, Holt's chain and indicates its advantages and defects and also the German chain " Orion."

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The Kegress caterpillar wheel has an india-rubber band and is, apparently, the best form produced up to the present time. This also is described in detail. The springing of tanks is then discussed.

The author lays down the following conditions as being essential for efficient action :—

Tactical mobility ; strategical mobility ; comfort for the crew.

As regards tactical mobility the chief requirements are that a tank should be able to cross a wide gap, to climb slopes of 45°, surmount vertical obstacles 1·5 metres high, to cross fords and shallow rivers and pass through walls and trees ; it is now demanded that tanks should be water-tight and able to travel in water, and to pass freely over areas covered with shell-craters. The modern tank satisfies all these conditions except those of water-tightness and ability to travel in water. Important experiments are now being undertaken by the French and Americans in this direction. There appears to be no difficulty in making a water-tight tank, but after going 100 km. no trace of water-tightness is left, as the continuous shocks and strains destroy any obturating material, even india-rubber. The first floating tank was the amphibious tank " La France," made by the French engineer Foenquinos. Many successful experiments were carried out with this tank in 1921–22 at Marseilles, with a crew of nine men and half a ton of baggage. Another example is that made by the Christie Company in America. It successfully crossed the Hudson in the autumn of 1922 in the presence of numerous officers and engineers. This tank weighs 6700 kilogrammes ; the author gives other interesting details about it and a photograph. There is also a photo of Medium Tank M 21, an American tank, which, owing to its great length and small height, is specially adapted for crossing shell holes.

As regards strategic mobility, one of the necessary conditions is rapid transport by its own power over great distances. During the war the French light tank was carried over great distances in a special lorry. Their " Char Schneider " of 14 tons was loaded on a special four-wheeled platform for towing. This system, if applied to great numbers of tanks, would require a large additional number of vehicles, with all their concomitant technical and tactical drawbacks. Since large numbers of tanks travelling long distances would speedily destroy any road surface some other method must be found. The solution of the question lies in the provision of " combined type " tanks, *i.e.*, tanks which are provided with caterpillars and wheels and can use them alternatively. There are at present two systems—the French " St. Chamond " and the American " Walter Christie." In the first, the wheels and caterpillars are entirely separate ; the former can be raised off the ground, leaving the tank supported on the caterpillar. The author gives a detailed description and plans of the tank Chenillette, and states that, according to rumour, it has been bought by the Spaniards and is being used in Morocco. In the Christie system there is only one transmitting system. The tank is provided with four double wheels and on them a caterpillar—the teeth of which fit into the groove between each double wheel—is fixed for movement across country. The caterpillars are supported in the middle by a pair of rollers on each side of the tank, which are

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lowered into position. The difficulty of steering when the caterpillars are in use, which involves independent movement of the off and near wheels, has been successfully overcome by an ingenious device which is described in detail. A full description and excellent photographs are given of each type of tank.

As regards "comfort for the crew," one of the most important points is the separation of the machinery from the crew in different compartments. Another point is good ventilation. The duties of the driver of the tank are very tiring and the operation of turning requires great exercise of strength. This matter is being remedied in the American Medium Tank M21 and in the English Mark D. Loopholes and slits for observation purposes are necessary in the newest types of tanks (Mark VIII improved Renault) they are provided by means of swiftly-revolving steel plates pierced with slits for observation purposes. In conclusion, the author remarks that tanks are yet in their infancy. The question of strategic mobility deserves careful attention. He thinks that the English Medium Tank D, with its great speed of 30 km. per hour, its excellent springing and efficient chain, may obviate the necessity of having combined tanks; on the other hand, the latter would require far less petrol but demand exertions on the part of the crew in changing from wheel to caterpillar and *vice versa*, an operation which must be done under cover (in this respect the St. Chamond system has an advantage over the Christie). Speaking generally, there is complete obscurity amongst the Central Powers about the significance of this new arm, whilst in England and America, considering the present state of their development, there is a tendency to overestimate their value.

A.H.B.

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*THE MILITARY ENGINEER.*

*May—June*, 1924.

*American Roads.*—The number of vehicles registered in the United States is estimated to reach 20,000,000 by the end of 1925. Under the Federal Highway Act of 1921, a connected system of main, inter-state and inter-county roads, comprising 6 per cent. of the total highways of the country, was selected to form the Federal Aid Highway System, its mileage approximating to 170,000. Up to March, 1923, 60,000 miles of this system had been converted to present-day requirements. It is hoped to complete the remainder in a ten-year programme.

Various materials are being used. Mention is made of gravel, concrete, bituminous concrete and brick roads, but the respective merits of each type are not compared. Problems of design and construction are being continuously investigated. The author quotes many interesting facts which have been established by research and experiment.

*New Type Motor Lorry.*—The Quartermaster-General is experimenting with an improved type of 5-ton lorry. The new type is a conversion of a standard four-wheel solid-tyred vehicle. A four-wheel flexible bogey replaces the ordinary rear axle, all six wheels being fitted with pneumatic

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tyres. The impact is reduced from 29,000 pounds to 7,000 pounds; the sub-soil pressure from 6½ to 2 pounds per square inch. Trials are proceeding.

*The Relation of Current to Tide.*—Tidal movements may be classified as Progressive Wave, Hydraulic, or Stationary Wave types. The author gives an explanation of each and shows how the tide in any locality can be identified from a study of tide tables, and hence the direction and strength of currents at any time determined.

*Use of Teleferica in the Italian Alps.*—Teleferica, or Aerial Ropeways, were extensively used on the Italian front, where their principal applications were :—

(1) During active operations to provide a rapid means of opening communication with advanced troops, pending the construction of roads.

(2) To supplement road communication in winter, when conditions became difficult.

(3) As a temporary means of crossing gaps, where bridges had either been demolished or rendered impassable by floods.

Troops on Mt. Grappa were supplied by a line 3,500 metres long, with a carrying capacity of 8 tons every 30 minutes and a maximum load of 1,000 pounds. Lines were usually duplicated, power being supplied by petrol engines.

*The Evolution of the Nautical Chart.*—Work of the U.S. Coast and Geodetic Survey Department. A complete account of the methods employed in the production of a chart.

R.I.M.

## *CORRESPONDENCE.*

### AUSTRALIAN SHEEP RUN.

To the Editor, *R.E. Journal.*

DEAR SIR,

The two enclosed diagrams of devices used on a sheep run in South Australia may be of interest.

1. *Wire Gate.*—This is sometimes made 30 ft. in width for large mobs of sheep. The strands forming the gate are made of twisted soft wire, so that the gate, when opened, will lie on the ground without coiling up. The lever post is usually tied back to the strut of the gate-post, and the chain on the lever is often attached to this strut instead of being fixed on a separate post, as shown in the diagram.

2. *Wire Ties.*—These are used in the place of nails for attaching timber to timber, as in stockyard rails.

Yours faithfully,

R. U. H. BUCKLAND, *Major-General.*

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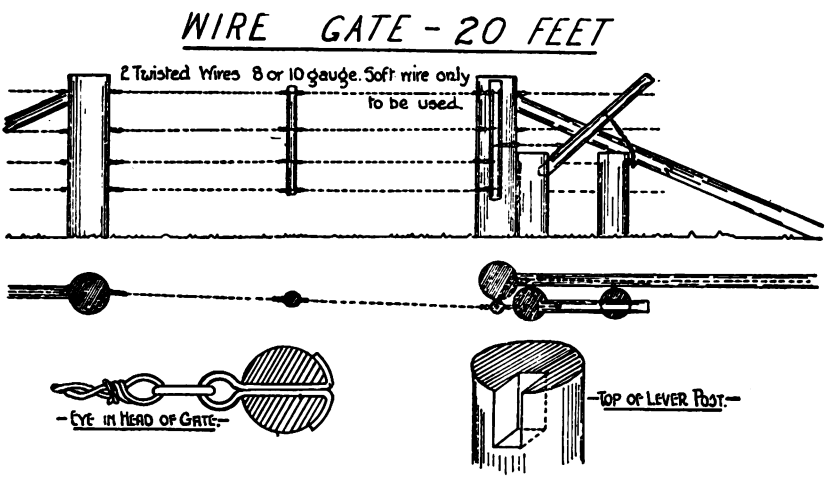
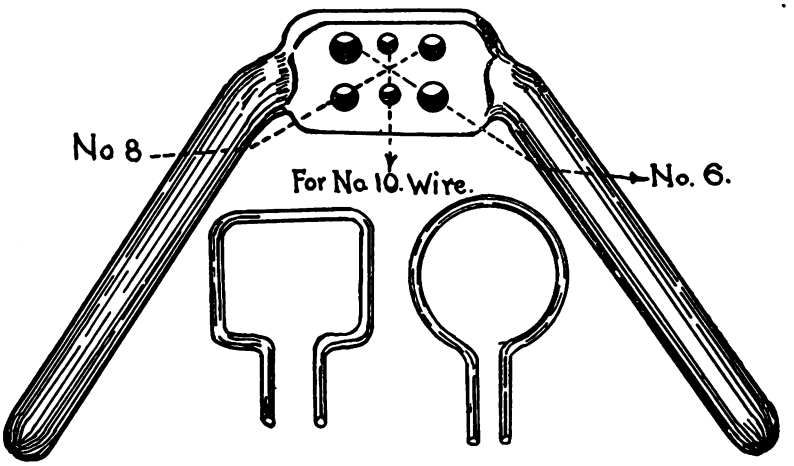
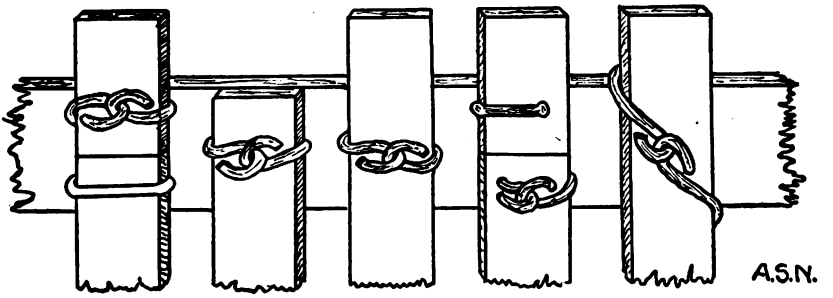



-TWISTER FOR MAKING WIRE TIES.-




-BEFORE TYING.-




-EXAMPLES OF TIES.-

The twister is made of steel or an old file or rasp, the holes in it being bored in pairs to take, say, Nos. 6, 8, and 10 wire. Ties for square and round timber are also shown. When the tie has been made, the ends are cut off and points hammered down as shown in sketch. The ends must not be corkscrewed.

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## WARMING AND COOKING FOR SMALL HOMES.

To the Editor, *R.E. Journal.*

SIR,

One of the institutions in which I am interested possesses an infirmary, which is a building, like many such, devoid of special design for its purpose and added on to from time to time without any regard to our modern ideas of economy.

The ruling body asked me whether I could give them my assistance in reducing the annual cost of heating their establishment, and possibly reducing their coal bill by utilizing the boilers and other miscellaneous heating appliances which seem to have accumulated from time to time without any definite policy.

Luckily, my answer was somewhat conservative and to the effect that, in my experience, the main economy in central heating was secured by reduction of labour in carrying coal, removing waste and keeping the place clean. But the reduction of the coal bill required some careful consideration.

I say luckily! Because on investigation I found that the establishment has a practically unlimited supply of unsalaried labour of old pensioners and other hangers-on; so the only items on which savings could be effected were reduced to coal consumption and periodical internal decoration.

I am indebted to my brother officers for two articles which have recently appeared in the *R.E. Journal* on central heating. I turned to these again with redoubled interest and absorbed much wisdom from their perusal.

But I could not find all I wanted; so I turned to the open market and made enquiries amongst my friends who had centrally-heated houses, and amongst the catalogues of firms professing to install central heating according to the latest modern developments.

I give the results of my enquiries for such as they are worth, not because I think they should be a model on which to base other similar schemes, but in order to provoke discussion and eventual enlightenment on a question which I humbly think has been a good deal neglected from an economic point of view.

The question of central heat production is going to have a greater importance than is generally attributed to it by the general public, which is content to view its public buildings, beautifully warmed in winter, and occasionally its private houses equally comfortable, as accomplished facts without enquiring how the desired result has been attained or whether it can be improved either in efficiency or economy.

When I was in Canada, some little time ago, I heard of a scheme for supplying heat to groups of houses in townships on exactly the same principle as water or electricity is now supplied. Now that I am in France, I find that there is a scheme on foot to erect superior grade mechanics' houses on disused bastions of the defences of Paris and to supply them from central stations with water, light and heating at a fixed rental to include all these conveniences.

So the central heating scheme is before us and it behoves us to study it just as we have studied the supply of gas, electricity and water.

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After a good deal of investigation and, possibly acting in accordance with my own prejudices, I decided on the low-pressure hot-water system. I may mention that I had long experience of the hot-air system as applied in three different countries and I did not like it. So the pipeless system did not enter into my calculations.

When I use the word "heat" I imply that the temperature in the room or building under consideration is to be raised to and maintained at between 60° and 65° Fahrenheit, with an outside temperature of 30°.

This I assume to be the average problem to be dealt with in England and the Lowlands of Scotland.

Radiators are now made of any pattern to suit the fancy. Many catalogues can be found in the trade which give very full information on this subject. A favourite method in England appears to be to install these under the window-sills, so that any leakage of air from outside should pass over the radiator and so be warmed as it enters the room. This system is apparently favoured by the Paris scheme. But it has its dangers in very severe weather, and it is not much liked in Canada, where an incautiously opened window might suddenly have the effect of cracking a radiator.

When the building to be heated has more than one story, the number of square feet of radiator surface in the second and third story, etc., can be reduced and allowance must be made for the heating surface of the communicating piping.

Now, 1 sq. ft. of radiator surface will heat 50 cub. ft. of air space per hour, roughly, so that 1,000 sq. ft. will heat 50,000 cub. ft. of air space per hour.

It requires 144 British thermal units to heat 1 sq. ft. of radiator surface per hour.

Coke broken of suitable size and good grade produces 8,500 B.Th.U.* per lb.

Therefore 1,000 sq. ft. radiator requires $\frac{144,000}{8,500}$ lbs. = 17 lbs. of coke per hour, assuming first-class stoking and absolute unwasted combustion, Add $\frac{1}{3}$ for mains' losses, cooling and imperfect stoking, say 23 lbs. per hour altogether.

So for 24 hours' heating of 50,000 cub. ft. of air-space we require 23 lbs. × 24 = 5 cwt. of coke.

Or, to put it in more convenient figures :—

1 cwt. of coke will heat 10,000 cub. ft. of air space per 24 hours.

The quality and gauge of the piping for a large scheme can be specified with any exactness to please the designer, but in small schemes, as a rule, one has to be content with the local supply available and the limitations to which the workmen are accustomed.

One installation which proved very satisfactory had one-inch piping

* Theoretically, 1 lb. of coke will produce 12,000 B. Th. U., but it depends on the pattern of the boiler, the draught in the chimney and manner of stoking as to how much of this heat is wasted and how much is absorbed by the water in the hot water boiler. The figure 8,500 is only applicable to the best boiler work and for the average house it would be safer to estimate for only 6,500 B. Th. U. being available per lb. of coke burned.

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throughout ground floor rooms and passages, and two-inch piping running along the skirting-boards of the first floor, connecting a correspondingly reduced number of radiators in the rooms with a final outlet into the open air of one-inch piping.

I have taken coke as the basis for my calculation. The corresponding figures for anthracite or for good steam coal are: 10,000 B.Th.U., so that 10,000 cub. ft. of air space require 90 lbs. per 24 hours for heating purposes.

It is possible that at some future date gas, and even electricity, may be utilized for heating purposes. So I venture to give the connecting link in B.Th.U.

One cub. ft. of gas produces 450 B.Th.U.

One therm of gas=100,000 B.Th.U.=30 Board of Trade units of electricity and 1,000 Watt hours=$1\frac{1}{3}$ H.P. hours.

I do not pretend that my calculations give anything more than a very approximate estimate of the fuel consumption and I am inclined to the belief that they rather overstate the requirements for an average British winter. It must be remembered, however, that though the winter may be mild it may last for a long time, like the one just concluded, so the estimate has to cover the possibility of a very severe winter or a long comparatively mild one.

So much for my figures and calculations! But I have failed entirely in collecting data for working out the size or design of the furnace and boiler required to produce the results I have endeavoured to work out.

Would one of your contributors favour me with some information on this subject?

Trade catalogues give illustrations of boilers and furnaces producing a given number of B.Th.U. per hour, but I have learned by experience to be somewhat sceptical of these designs and their promised performance.

My attention was next directed to the modern economical devices for supplying hot water to small houses and the latest developments in cooking ranges.

There is a very useful pamphlet prepared under the auspices of the London County Council, discussing the developments to be sought in superior artisans' houses, as well as in those for humbler members of the working population.

There seems to be a general consensus of opinion that hot-water circulations dependent on the boiler attached to the kitchen range use up 30% of the fuel allowance. They have this further disadvantage that the water is not really hot (180° Fahr.) unless the dampers are drawn out for that special purpose, and if there happens to be cooking going on at the same time when hot water is required, the oven suffers from robbery of heat or else the whole system is run at great pressure and so hastens its deterioration.

Some years ago I abandoned the kitchen range system for hot-water circulation in Government quarters and put in a separate furnace and boiler in connection with the existing cylinder, cutting out the old saddle boiler from behind the kitchen range.

The drawback of this system I found to be that nobody but the gardener could contrive to bank the fire so that it would last throughout

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the night. This proved a great inconvenience, as it meant having the gardener on duty at ten o'clock every night. Otherwise the system proved to be economical and the furnace, being omnivorous, got rid of a good deal of kitchen refuse which in ordinary country houses would have been devoted to fattening the pigs.

Certain gas companies have, in the last few years, been advocating their gas water-heaters with what they call a Thermostat installation.

Opinions differ as to the efficacy of these. In the first place they are expensive in first cost, and the gas companies are not always willing to let them out for hire.

There were some of these on show at the Exhibition in Olympia last March and I extracted the calculations from the experts in charge, who wanted to put me off with the bald statement that the cost was 3d. per bath of 20 gallons. But it took, so far as I can recollect, 20 minutes to prepare the water for circulation, after which time it was continuous.

I then tried the several Geyser companies that were exhibiting their wares. These are certainly a great improvement on the terror of former years, but they are expensive to install for more than three taps. These experts again tried to put me off with the 3d. per bath of 20 gallons.

On checking the calculations of my friends I found that they based their results on the London County Council specification of gas producing 500 B.Th.U. per cubic foot and costing 8d. per therm.

Personally, until I am convinced by better arguments to the contrary, I am in favour of the Thermostat water-heater.

If the pipes are nicely laid and exposed where wanted they supplement the central heating of a small house. If the house is already sufficiently warmed, it would, of course, be better to insulate the pipes, except in the linen cupboard, in which the cylinder should find its home, and in the bathroom itself, when the circulating water should have a by-pass to warm the towel rack.

The gas-heater can be turned off in summer and only lighted when actually wanted.

Having accepted the gas water-heater, we now turn to the kitchen range itself.

My own proclivities are in favour of gas cooking and I would gladly see the kitchen range and consequent sweeping of chimneys abolished.

But would our attendants, on whom our comfort in declining years so greatly depends, view the subject in the same light?

Poor things! They do suffer from the heat of the kitchen in summer-time, and it is no doubt a severe trial to have to cook in parts of July and August. But how long does the real summer weather last? Three months, with luck four, and during the remaining eight months of the year there is much comfort and consolation to the worker in a cheery kitchen fire.

So I fear the kitchen fire must remain till a new generation of assistants arises and we must go to the expense of a gas-cooker for use in summer and to supplement the kitchen range.

Now I have got to the subject of ranges I have to make a further confession of faith. It is that the kitchen range of the average British

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12-room or 10-room house is an exaggerated anachronism. Why need it be so large?

Why need it be built into a cave in the wall so that whenever anything has to be put right a bricklayer as well as a stove-setter has to be employed?

Why not introduce everywhere the Canadian cooking range, standing like a table away from the wall with the stove-pipe running up out of reach, so that the operator can walk round it and keep it clean?

Such a stove as I have in my mind stands on legs, so that the paving on which it is set can be kept religiously swept and there is no harbour for black beetles and mice.

Many firms in London make and stock these ranges, but they are not often met with in middle-class houses.

The County Council pamphlets above alluded to recommend these ranges for artisans' houses, and the only objection so far encountered by me in course of discussing their introduction to workmen's houses is that children might possibly run up against them and burn themselves.

It was in vain for me to protest that these ranges have been in use in Western Canada for many years without serious diminution in the rising generation. I was still met with the rooted conservatism in favour of buried ranges where the cook has to put her head under the arch of the chimney-piece to see what is going on and stands in her own light.

One more grumble and I have done. Many of us, in our declining years, are martyrs to gout, rheumatism and arthritis. Are not these ailments in a great measure traceable to the prevalence of hard water?

Water-softeners are obtainable in the market at a certain price. The cost is considerable, but I am confident that the rising generation of house-builders has only to press their efficacy on the public to render them sufficiently popular, so that the price, which is now almost prohibitive, may be brought within the compass of a modestly-furnished purse.

Some of us of the old guard manage to hang on to a good old age in spite of gout and rheumatism, but if these latter ailments could be exorcized even by a little, our declining years would be made the happier and we would go down to our graves in a spirit of thankfulness to those who have contributed to our comfort.

J. A. FERRIER.

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## TIDES.

To the Editor, *R.E. Journal.*

DEAR SIR,

May I offer the following criticisms on the correspondence entitled "Tides" in the June number of the *Journal.*

Not being acquainted with Mr. Louis Stromeyr's theory, which, he remarks, renders a gravitational field of force as a plenum of energy, and so prevents him from looking to attraction as an explanation of the tides, makes one diffident about criticizing his idea of tidal causes,

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which is based on that theory. However, his letter strikes at the roots of so much that one has become accustomed to take for granted that I venture to bring forward some reflections on the modern view of the constitution of matter, for without a fairly good idea of " matter " we shall probably fail to discover the reasons underlying the effect that matter has on matter.

These reflections tend to confirm one's belief, in my opinion, in the theories of Newton and Laplace as to tidal action, the equilibrium theory of the former and its extension in the dynamical theory of the latter.

As I understand Mr. Stromeyr's letter, he firstly criticizes tidal theories, which take into account lunar attraction, and which are therefore not admitted by him. He then briefly states his own conclusion, but without supporting data, perhaps that is contained in his " gravitational theory," with which I am unfortunately not acquainted.

We find Mr. Stromeyr repudiating the existence of the force of attraction that mass has on mass; he says this still implies " action at a distance." Men of science admit that the exact mechanism by means of which mass attracts mass is not understood; this largely because the constitution of matter itself has not yet been fully determined. Much, however, is now known about matter and something about space.

Mr. Stromeyr only makes a slight reference to electrical matters, but since the modern conception of matter is that its structure is electrical, I shall here probe somewhat deeper into this field.

The atom, the old-time basis of matter, has now itself been sub-divided. It is known to comprise one or more electrons, the units of negative electricity, which have a definite mass value of about $\frac{1}{1850}$ of that of a hydrogen atom, and besides, a nucleus of positive electricity, which has so far evaded isolation.

Some of the properties of this elusive positive nucleus are known, and others are in the process of coming to light. Its mass, for instance, appears to be much greater than that of an electron.

The arrangement, or configuration, of the electrons and positive nuclei, is probably the factor determining the atom and its properties. The electrons, there is little doubt, are usually, if not always, in a state of some type of orbital motion.

The different effects of mass in motion and mass at rest are well illustrated by the powerful water jet through which a sword will not pass, and by the smoke vortex ring which passes through a smoke cloud as if an individual structure.

Bearing in mind the dissimilarity existing between the positive and negative " ultimate particles," may we not justly conjecture that the electrical inter-actions between two atoms of matter may cancel out?

Consider two identical atoms, electrically neutral, that is, each with its normal constitution of positive and negative " particles " of electricity, and these in normal motion.

The indications are that the electrons particularly inhabit the surface layers of the mass, anyhow they are comparatively easily dissociated from the mass.

The first effect between two atoms would then be a mutual repulsion

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between the nearest electrons in each. One might then suspect an opposite reaction on the remainder of the atom, resulting in an attraction of mass for mass. Such a reaction would account for attraction, such as exists in the force of cohesion, where small masses are in intimate contact, also for attraction between planets, where large masses can act over greater distances.

Having considered the possibilities in this way, even though it may not be a completely true explanation which I have hazarded, I conjecture that an explanation proving that mass does attract mass will be arrived at by some such reasoning. It is not surprising that mass attraction cannot be explained at present, seeing that our knowledge of the constitution of matter is still incomplete.

Now as to "space," which, Mr. Stromeyr says, a "field of force" cannot occupy, but which "energy" can occupy, if I understand his meaning, such a differentiation seems to me impossible, having due regard to the meanings of the terms "force" and "energy." The word "occupy" is ambiguous, but I will not make a quibble on that. Space, of course, is a medium through which various transverse waves can be and are propagated at a finite velocity, that is to say, in the interval of time between the generation of the wave and its reception, the medium is in a state of wave strain, and therefore a seat of energy.

It can be shown also, that prior to the wave being propagated, space may be in a condition of static strain, and therefore a field of force.

Consider a wireless transmitting aerial; with the initial charge of the aerial wire, space is "lifted" into strain, ready to propagate its strain in the form of a wave, immediately the stress is suddenly removed.

While the charge is "held," strained space is a field of electrostatic force.

Near a magnet we have strained space as a field of magnetic force.

A mass of matter, having a mechanical force applied to it is a field of mechanical force, and so on.

We say nowadays that ether permeates all space, but what is ether?

We don't know all about it, but it is certainly something which can be set into vibration at the enormous frequencies of X-rays, light waves, wireless waves, and so on.

It is also something in which certain currents of electricity, known as dielectric currents, can be made to flow, though unwillingly. Or, put into other words, it is something which appears to contain positive and negative electrical particles, which can be displaced and so become currents of electricity in space during the time interval of displacing. In considering the wireless aerial, we had, first, the electricities displaced forming an electrostatic strain; this strain in righting itself gives rise to displacement currents of electricity in space, which in their turn give rise to electromagnetic space strain, which again gives rise to further electrostatic strain, and so the wave is passed on.

Compare the static condition at the crest of a water wave and dynamic condition half way between crest and trough.

Perhaps a working hypothesis would be to imagine the ether of space to consist of positive and negative electricities in a neutral and immaterial configuration. What constitutes the difference between electrostatic

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and electromagnetic force in space has yet to be explained—some difference in the motions or positions of the electric particles, perhaps.

Now, as to Mr. Stromeyr's query on antipodal currents, does not the *Encyclopædia Britannica* explain the causes for these, under the heading of tides? I refrain from reproducing the arguments.

As to Mr. Stromeyr's final conclusion, I am able to believe that a distortion of both earth and water is set up which possibly gives rise to a wave of strain, but I think these effects would be due to attractions by the moon and sun, and cannot be solely due to the earth's rotation.

Something besides mere rotation is required to explain the generation of this wave.

E. D. CARDEN, *Major*, R.E.

DEPÔT BARRACKS, YORK,
*18th June*, 1924.

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## TROUBLES OF AN OFFICIAL HISTORIAN.

THE MINES AT HILL 60, 17TH APRIL, 1915.

To the Editor, *R.E. Journal.*

SIR,

May I again ask your assistance in compiling the official history.

I should be very much obliged for any information that would help to clear up the mining situation at Hill 60, on 17th April, 1915. The Army, Corps, Divisional and Infantry accounts agree that three mines (or six mines in pairs) were fired at 10 seconds interval; the artillery opened when the first mine was fired, the storming party advanced directly after the third explosion.

The diary of the C.R.E., 5th Division, says: "for this operation see the diaries of the 59th Field Co., R.E., and the 1/2nd Home Counties Field Co." The 59th Co. diary contains nothing on the point; that of the 1/2nd Home Counties Co. speaks of three mines fired by the 171st Co., R.E., and of finding R.E. for the storming party and consolidation. The diary of the 171st Tunnelling Co., only formed on the 9th April, states that it loaded *two* mines, not three, with 2,700 lbs. black powder and fired them. Some other unit apparently made the galleries and the third mine.

The 28th Division, which preceded the 5th Division in the Hill 60 sector, is believed to have initiated the mining scheme when it took over from the French, who lost the Hill on the 10th December. There is, however, no mention of mines in its diaries, except that the 1st Northumbrian Field Co. has an entry of an officer being wounded "returning from the mines."

I am now compiling the volume on 1915 (France) and should be glad of any details of R.E. doings in that year. The R.E. war diaries contain very little, as members of the Corps were too busy doing work to have time to write about it.

Your obedient servant,

Audit House, J. E. EDMONDS.
Victoria Embankment, E.C.4.

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## WAR PHOTOGRAPHS.

THE Imperial War Museum, Imperial Institute Road, South Kensington, S.W.7, to which address its quarters have now been transferred from the Crystal Palace, contains a very complete pictorial record of the War, comprising upwards of 100,000 official and unofficial photographs depicting scenes and incidents of interest to the three Services in all theatres of operations during the period 1914–1919.

In addition, the Museum possesses very extensive records in the form of maps, charts, aerial "oblique" and "vertical" views, and other matters of topographical interest.

There is also an extremely valuable collection of photographs of Naval interest dating back to 1860, in which war craft of all types and nationalities, from battleships to coastal motor boats, are shown, as well as views of mercantile vessels, portraits of Naval notabilities, etc.

Copies of the above-mentioned photographs may be secured on application to the Museum, and orders can be dealt with by post where it is not convenient for the person interested to call and inspect the records at the Museum.

This very valuable collection of photographs has already proved of great use for illustrative purposes to authors of official, regimental and Divisional histories, memoirs and other War literature; to lecturers on matters of Naval and Military interest who require to illustrate their lectures with lantern slides; and to individual officers and men who desire to illustrate their own personal diaries of the momentous events which they experienced during the period of the Great War. Upwards of 150,000 prints and lantern slides have been sold to the public, included in this figure being 800 prints and slides actually sold by the Museum in its new quarters at South Kensington, in spite of the fact that the galleries are not yet open to the general public.

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# *THE DEFENCE OF KUT-EL-AMARAH.*

*By* Major E. W. C. SANDES, D.S.O., M.C., R.E.

THE battered survivors of General Townshend's force reached the outskirts of Kut-el-Amarah on the 3rd December, 1915, grim, exhausted, and thirsting for revenge, and, ten miles to the north-west, the Turkish legions followed cautiously in their track, warned by the lesson of Ummal-Tabul that there was still fight in the British Lion. Hovering around the flanks and rear of the British force were bands of marauding Arabs, careful to keep out of range, though eager for loot and the murder of stragglers—foul birds of prey waiting to swoop down on the wounded and helpless. Townshend had made a masterly retreat after the fights at Ctesiphon and Ummal-Tabul, and his men had marched seventy-six miles across the desert in two days, outdistancing the foe yet retaining their courage, discipline and morale. It was a fiery test, recalling the retreat from Mons, with sun, dust and thirst in place of German bullets, but British leadership and the grit of the rank and file triumphed in the ordeal. The Turkish wolves licked their wounds, and the pack gathered for a final rush upon the prey.

General Townshend decided to halt at Kut, and to defend it till relieved, in order to hold up the Turkish advance into Lower Mesopotamia. Reinforced by half a battalion of West Kents and the 14th Hussars at Aziziah during the retreat, and by 1½ battalions of Indian infantry on reaching Kut, he found himself in command of 10,400 combatants, of whom 1,500 were cavalry; and, when the cavalry were sent away on the 6th December, he had only 7,400 infantry to defend a front of 2,700 yards across the loop of Kut, to picket three miles of the river bank, and to garrison Woolpress Village across the river. Coming down upon him from the north-west were six divisions of Turks under the German Field-Marshal Von der Goltz, the advanced guard being stronger than the whole British force; and behind him was only the 28th British Brigade, which was then leaving Amarah, 100 miles away. A desperate position if ever there was one!

When Townshend entered Kut there were practically no defences other than those designed to resist an attack by Arabs, viz., a line of four blockhouses across the Kut loop of the Tigris, connected by a wire fence, and ending in a walled fort at the north-eastern extremity on the river bank, downstream of the town. Townshend had been so uniformly successful during his advance, the nucleus garrison at

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Kut was so small, Arab labour was so unsatisfactory, and the time so short, that no defensive system was ready for the retreating British force on arrival which would enable it to resist a determined attack by large masses of Turks with good artillery. By the grace of God, the determination of our men, and the excessive caution of the advancing Turks, there was just—and only just—time to make a first, though frail, barrier against the enemy's onslaught before it came. As the tide of the enemy rose and his waves mounted higher, so was that frail barrier, the front line, strengthened and supported by other lines; and when, on Christmas Eve, the storm broke from the north-east, the Fort, at that end of the front line, was just—and only just—strong enough to withstand the shock and save Kut. There can be little doubt that, if the attack on the fort had taken place a week earlier and if the enemy had backed up that attack with a determined assault on the north-west section of our defences upstream of Kut, pressed home regardless of losses, the garrison would have been overwhelmed and Kut would have fallen in December. Why, then, did he delay his attempt and fail to use sufficient force? Chiefly, I think, because of his respect and fear of British prowess and tenacity, but partly owing to the difficulty of transporting sufficient ammunition from Baghdad to Kut in the time available, and also because of the advice of Von der Goltz.

Now the German Field-Marshal was a cool and experienced strategist and a student of military history. He remembered the fate of Bazaine in Metz and of Massena in Genoa. He knew that an immediate assault on Kut, driven home with masses of bayonets, would probably lead to victory, but only at the cost of very heavy casualties which the Turks could ill afford when so far from Anatolia. He guessed that England would surely send large reinforcements to Mesopotamia to retrieve the ill-fortune of the recent British advance, and that he would need all his resources to meet that invasion. And lastly, he was well aware that, if he could contain Townshend till the river flooded the country in January, the chance of the rescue of the beleaguered force was small indeed. The impetuous young Turkish general, Khalil Pasha, leading by the nose his vacillating superior, Nur-ed-Din, wished to avenge the tactical defeat of his countrymen at Ctesiphon, and the fiasco at Ummal-Tabul, by an immediate assault in overwhelming numbers; but the wily old German had his way, and such attacks as were made prior to Christmas Eve were not serious, while the serious attempt on that day was directed only against the fort and was not pressed strongly elsewhere. Von der Goltz saw that the main body of his enemy was only then assembling in Lower Mesopotamia and that Townshend's troops would soon be of minor importance, so he rightly prepared to strike at the heart rather than the head of his foe and to husband his troops for that purpose. Thus the British were allowed time sufficient to organize

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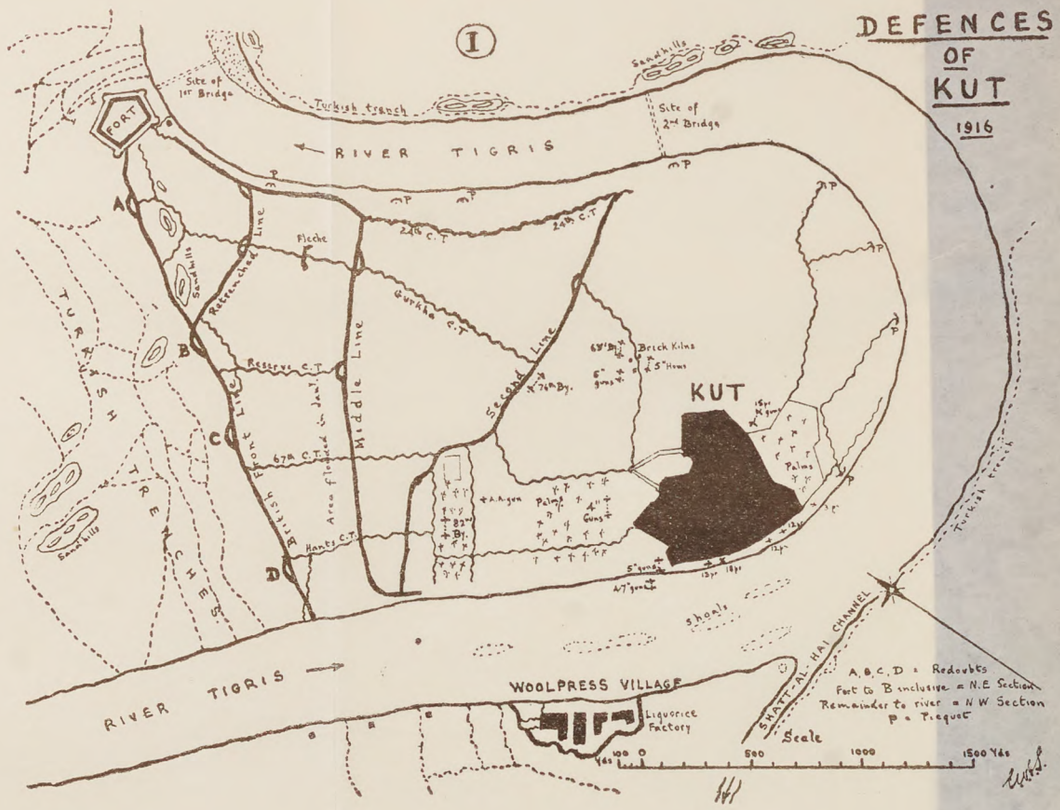


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their defence and strengthen their position, unsatisfactory though it was.

General Townshend had four weak brigades—the 16th, 17th and 18th Brigades of the 6th Division, and the 30th Brigade of the 12th Division—and there was only one British infantry battalion in each Brigade, the remainder being Indian. The position of his front line was more or less determined by the existing line of blockhouses and the fort. The area thus enclosed gave a suitable space for manœuvre. The blockhouses temporarily covered the digging operations in the 2nd Line (see *Diagram* I), which had already begun, but they were demolished on December 7th when the work was well advanced on the four redoubts A, B, C and D, which were to replace them, by which date, also, the 2nd Line defences were almost complete. By December 12th the redoubts had been finished, and, three days later, they had been linked up with traversed trenches to form a continuous front line. Meanwhile the defences of the fort had been improved, and the village of Woolpress fortified, so that by the 15th December, only 11 days after the troops had actually entered Kut, there were two strong lines of defence to withstand the Turkish attack. The defensive system was then completed by a "Middle" Line, which was dug before Christmas, and a "Retrenched" Line (see *Diagram* I), which was excavated immediately after the abortive and desperate assault on the fort on Christmas Eve. Communication trenches had to wait their turn. For a long time there were very few of them—far too few to permit of reinforcing the front line hurriedly except by an advance across the open plain—but each work had to be viewed in the light of its immediate urgency and the most essential works were the fire trenches.

The sections, or zones, of defence around Kut were allotted as follows (see *Diagram* I):—

(*a*) The *North-east Section* (or zone) of the land front to the 17th Brigade under Brig.-General Hoghton. This zone included the fort and extended in the front line to Redoubt B, the latter first exclusive but later inclusive. In depth this zone included the Retrenched Line and the portion of the Middle Line in rear of it.

(*b*) The *North-west Section* (or zone) to the 16th Brigade under Major-General Delamain, or to the 30th Brigade under Major-General Sir C. Melliss, alternately. This zone included the remainder of the Front and Middle Lines. The brigade, not in occupation, formed the General Reserve in Kut itself.

(*c*) The *Kut, or River, Section* to the 18th Brigade under Brig.-General W. G. Hamilton. This section included Woolpress Village on the right bank (2 battalions), Kut itself, and the three miles of river bank from the town to the fort. The bank was guarded by pickets.

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The 2nd Line was to be manned by the General Reserve in case of a threatened assault, being the final line of defence and covering all the artillery positions. Owing to the distance of the North-east Section from Kut, and its exposed position, it was difficult to arrange a relief for the 17th Brigade, so that brigade remained permanently in the front line and garrisoned the fort. Similarly the difficulty of relieving the battalions in Woolpress Village fixed the 18th Brigade in the Kut, or River, Section.

The vital portion of the defence was certainly the North-west Zone (D) where the front line was only 1,500 yards from Kut. The loss of the adjacent zone, the North-east, would have badly crippled the defence and particularly the artillery observation, since the observation post in the fort gave a base of over 3,000 yards to the other terminal in Kut town. But such a loss would not necessarily have been immediately fatal. On the other hand, the loss of the North-west Zone could hardly fail to result in the capture of many of our guns and of Kut town with all our supplies and munitions. It would also entail the isolation and surrender of the garrison of Woolpress Village. The river being impassable except for small detachments, no course would then remain open but a desperate attempt to cut a way out of the trap, northwards through the maze of Turkish trenches, without artillery or transport, in hand to hand conflict with superior numbers of the enemy.

General Townshend fully recognized the importance of the North-west Zone and arranged accordingly that his two best brigades, commanded by his most experienced officers, should relieve each other frequently in that zone, so that the troops in that part of the front line should always be as fresh as circumstances permitted. Every British gun could bring a devastating fire to bear against an assault on the north-west front, and machine-gun fire from Woolpress Village could enfilade it at effective ranges.

The garrison of Woolpress covered Kut from the west. The troops, however, were in a precarious position. They could not be strongly reinforced in case of violent assault, and they depended for their very existence on the survival of one steam tug (the *Sumana*) and a couple of motor boats which brought them food and ammunition across the river at night and were bombarded by artillery during the day. But the risk had to be accepted. If Woolpress had not been occupied, the enemy could have enfiladed our trenches and artillery positions, and Kut would have been uninhabitable under concentrated fire at close range. What, then, would have happened to our wounded, and to the 4,000 Arab women and children in the town whom the Turks would not allow to leave? Woolpress Village on the left flank, and the fort on the right, made the defence of the Kut peninsula possible.

Townshend's scheme of defence, as described in his book, was to

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work on interior lines against the foe, throwing out a " Minimum Force " to the north-east, another to the north-west, and retaining under his control a central " Maximum," or Striking, Force, in or near Kut. His scheme was theoretically sound, but unfortunately the " Maximum Force," allowing for pickets, internal security and the garrison of Woolpress Village, was no larger than either of the two " Minimum " forces, and it could strike only to the north-east, north, or north-west, because the Tigris was an impassable obstacle. The truth is that, for a vigorous counter-offensive, the occupied area was too large for the British force, yet no smaller defensive position was available. If the " Maximum Force " delivered a counter stroke, the general direction of that attack would be known to the Turks, and the element of surprise would be lacking except as regards time ; and even the time of attack was very difficult to conceal, as Kut was full of Arab spies who swam the river to carry news to their masters, the Turks. A reference to *Diagram* II will show, from the shape of the network of Turkish trenches opposing our front line, that the enemy expected a British attack north-eastwards from the Fort, though I should explain that both *Diagram* I and *Diagram* II show the systems of trenches as more or less completed later in the siege. Early in 1916 they were not quite so elaborate.

It has been said that Townshend should have cut his way out of Kut when hopes of early relief had vanished. Till the floods came in January he confidently expected an early relief. Up to that time he was threatened with an assault by large masses of Turks, close behind the force containing him, so he devoted his energies to strengthening his position in order to save his force from annihilation. When the floods came in January, the bulk of the Turkish troops moved down-stream to Sannaiyat and Falahiyeh to resist the Relief Force, only a few thousands remaining in front of Kut on the heavily entrenched tracts showing above the swamps. Now supposing that the British could have forced a way along those fortified strips of ground, through line after line of wired trenches and under heavy artillery fire, obliged to abandon most of their guns owing to the mud and the shortage of horses, where were they to go ? The only possible direction, which was of any use, was eastwards towards Sannaiyat and Falahiyeh, since the Tigris was impassable, *i.e.*, they would be advancing directly towards the main body of the Turkish Army, which was entrenched to resist the Relief Force. Again, supposing that they won through to Sannaiyat—a distance of 18 miles—could they join the Relief Force which was on the *right* bank and well downstream of that place ? Such would seem to be some of the considerations which kept Townshend in the Kut peninsula, awaiting the chance of co-operating with the Relief Force when it came in sight of Kut, but unable to fight a way out to join it.

The British artillery in Kut was slightly more powerful than the

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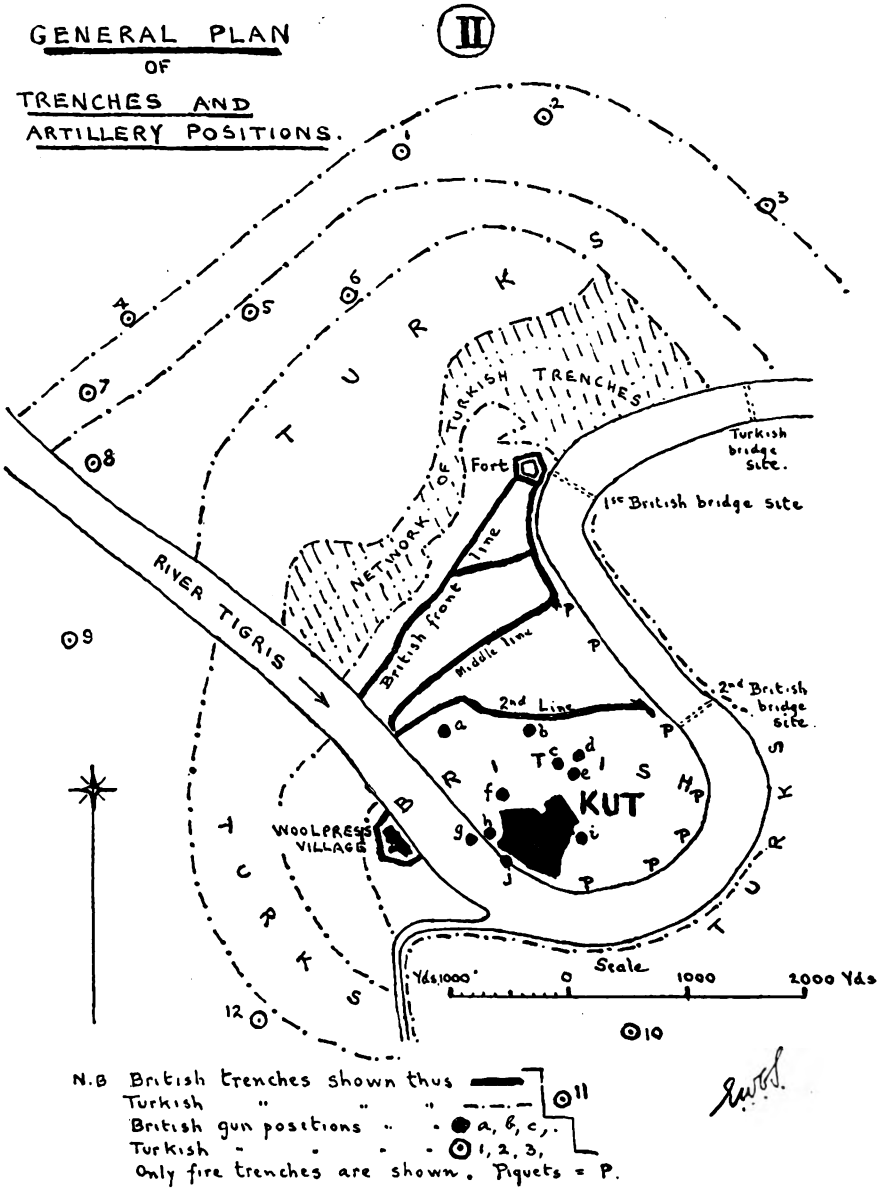


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Turkish artillery around it. *Diagram* II shows the various gun positions by letters or figures. Taking the British first, the following was the approximate distribution of guns :—

(*a*) 6 18-prs. (82nd Battery, R.F.A.)
1 13-pr. (anti-aircraft)
(*b*) 6 18-prs. (76th Battery, R.F.A.)
(*c*) 2 5-in. guns
(*d*) 6 18-prs. (63rd Battery, R.F.A.)
(*e*) 4 5-in. howitzers
(*f*) 2 4-in. guns
(*g*) 4 4·7-in. naval guns (afloat)
(*h*) 2 5-in. guns
(*i*) 4 15-prs.
(*j*) 1 18-pr.
1 13-pr.
2 12-prs. (naval)
1 3-pr. (naval)
} on the river front.

a total of 42 guns and howitzers.

The distribution of the Turkish artillery was :—

(1) 4 12-prs.
(2) 4 9-prs.
(3) 2 40-prs. (12 cm.)
(4) 2 large naval guns (doubtful calibre)
(5) 4 16-prs.
(6) 2 9-pr. howitzers
(7) 4 40-prs.
(8) 4 40-prs.
(9) 4 16-prs.
(10) 1 16-pr.
1 18-pr. (British)
(11) 2 30-pr. howitzers
(12) 1 30-pr. howitzer

Excluding an antiquated mortar of huge calibre, the enemy had thus about 35 guns and howitzers ; but, with the exception of the two large naval guns, which were soon out of action, and the 18-pr. which seldom fired, none of the Turkish artillery had high-explosive shells, and neither side had any really heavy artillery. Also, neither side used poison gas. Exposed to heavy shelling with high-explosives, Kut could not have lasted a month ; and, exposed to gas, the end would have come in a few days, as there were no gas masks. To give them their due, the Turks fought cleanly.

The struggle for Kut lay then between two forces evenly equipped with artillery, avoiding the use of gas, but with the British only using high-explosives. The Turks slightly outnumbered the British and

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had large reinforcements close at hand, but the British were superior in training, discipline, fire-control and initiative. The Turks were poorly fed and had probably not too much ammunition, but they had no need to husband their ammunition very strictly. On the other hand, the British had ample food for two months, a large ammunition supply for their guns, and 800 rounds per rifle, but they dared not waste a single round. The Turks had excellent periscopes, a plentiful supply of bombs, and, after a couple of months, three German aeroplanes. The British had to manufacture their bombs and periscopes, and had no aeroplanes. And lastly, the Turks held the initiative and were in a seemingly friendly country, while the British were isolated, with their backs to the wall. It was a peculiar situation, and one difficult to describe in a few pages, but, having done so to the best of my ability, I will conclude with an account of the course of the siege which resulted from the decision to halt at Kut.

General Townshend's force marched into the Kut area on the 4th December, 1915, and the remnants of his shipping moored along the river bank. The Army Commander, General Sir John Nixon, had succeeded with great difficulty in making the voyage to Amarah, having been held up by Arab cavalry below Kut, so Townshend sent all his own shipping downstream as soon as possible after his arrival, keeping only one armed tug, a couple of motor boats, a few launches and barges, and his bridging train. He intended to use the bridge to maintain an active defence by transferring troops across the Tigris, when necessary, to operate against isolated bodies of the enemy. The bridging train did its part in enabling the 6th Cavalry Brigade to escape across the river near the fort on December 6th, before the Turkish investment was complete (see *Diagram* I), but the subsequent bridge higher up the river had to be destroyed after a determined attack by the enemy, a fate which was inevitable. The launches were lost with the bridge, and Townshend was thus practically isolated in the Kut bend on December 10th, and had only one tug, two motor boats, two small steel barges and about forty leaking *mahelas* (dhows) to enable him to send small parties of men across the Tigris. His intended active defence was then restricted to sorties northwards from his front line.

Every measure was taken to prepare Kut for defence. In addition to trenches and gun positions outside the town, internal communications were made or improved, lists of available supplies and stores were prepared and the supplies distributed, hostages were taken from the town Arabs as sureties for good behaviour, a Military Governor was appointed and police organized, mills for grinding grain were started, Arab labour gangs were marshalled, and buildings set apart for hospitals, offices, etc. In fact, the place hummed like a beehive, every man working against time. The Turks pitched their camp in the Shumran bend of the river, a few miles upstream, and busily unloaded stores and ammunition as they arrived, hurrying

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their troops off as quickly as possible to complete the cordon around the British and to dig as they had never dug before. Their guns were already in position by December 9th when they shelled the defended area severely, and, on the 10th, they threatened an attack on our unfinished front line, pouring in a heavy fire, but deterred from actual assault by accurate rifle and gun fire. The same thing happened on December 12th, and, during the next few days, the Turks pushed their trenches as close as possible to our North-west Section and to the fort. Then followed a lull while they prepared for the great attack on the fort on Christmas Eve. It was evident to all in Kut that a crisis was approaching, and they braced themselves for the ordeal.

During these early days of the siege, Kut was a paradise for the inventor, and, even to the end, the inventive genius had more than enough to think about. The Sappers and the R.A.F., in particular, out-Hiramed Mr. Maxim himself. There were no bombs, so the humble jam tin, gramophone needle, and detonator supplied the deficiency; there were no bomb guns, so old aeroplane cylinders, and even wooden battens and wire, replaced them; and later, as there were no anti-aircraft guns, a 13-pr. R.H.A. gun and carriage (minus wheels), suspended from a stake in a deep pit, found a new rôle, and was backed up by several machine-guns which were lashed to barrels pivoting on vertical spindles. Again, there were no periscopes, so the Arab ladies of Kut surrendered their mirrors, with weeping and wailing, for dissection by the prosaic Sapper. When coal was exhausted, the wooden timbers of the bazaar roofs fed the furnace of the tug *Sumana*; and, when wood itself was becoming scarce, the furnace was adapted to burn heavy oil in addition. One sad day a Turkish shell damaged the *Sumana's* main steam pipe. Immediately the Sappers turned out a passable fitting; and later, when another part was required, it was removed from a sister ship by the Relief Force downstream and dropped by aeroplane into the Kut area in response to a wireless demand. As there was no planking in Kut for bridging purposes, Arab front doors were collected and joined together with dogs made from verandah railings. And lastly, when the grindstone of a grain-crushing mill broke, a new granite stone was dropped 4,000 feet from an aeroplane and was spinning merrily in Kut within a few hours. I could write pages of description of the makeshifts employed during the siege, but space does not permit. Never did the Sapper lead a more thoughtful existence. The far-away look in his eyes, and the puckered brow, warned the world not to interfere with the mighty workings of the brain on which perhaps the cooking of to-morrow's breakfast might depend!

The long-expected attack on the fort came at last. Twenty guns opened fire on it at dawn on Christmas Eve, and a four hours' bombardment wrecked the walled defences of the north-eastern and eastern faces, driving the garrison to a stockade within the work itself. The Turks swarmed into the *débris*, and fought for hours with a

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gallantry only exceeded by that of the defenders, but they were ultimately ejected with very heavy loss. When darkness fell they renewed the attack and again captured part of the fort, but were held up after a fierce struggle; and, with a last desperate and unsuccessful assault before dawn, they gave up the attempt and retired, leaving the ground around the ruined work a veritable shambles. Kut was saved, and was never again seriously threatened; yet it was only saved because the enemy made the fatal mistake of restricting his assault to one small portion of our defences. His attack was a determined one, but merely local, and he was afraid to incur the heavy losses of a simultaneous attack on the defences of the North-west Zone. Also, the preliminary bombardment of the fort gave due indication of his intentions, and destroyed the element of surprise. Von der Goltz, who had watched the attack on the fort, now returned to Baghdad, convinced that a policy of passive investment was preferable to active assault; and Khalil Pasha, who was left in command in front of Kut, conformed with his wishes by bombarding the place frequently and heavily, but attempting no attack. When the New Year came, the Turks had nearly 30,000 men and 83 guns around and below Kut. There were then 3 Turkish divisions at Shumran (11,500 bayonets with 41 guns), 3 divisions containing Kut (12,900 bayonets with 24 guns), 1 division at Es-Sin on the left bank (2,500 bayonets with 18 guns), and at Shaik Saad, 30 miles downstream, 4 battalions, some cavalry, and a camel corps. At the end of 1915, therefore, the enemy could easily have assaulted Kut with 24,000 men supported by 60 guns, whereas the actual attack on the fort on Christmas Eve was carried out by only 5,000 men supported by 20 guns, and of those 5,000 men barely 2,000 entered the fight, since the supports refused to leave their trenches. It was a pitiful example of the sacrifice of a few brave men by the adoption of a policy which was neither one thing nor the other—neither a sufficiently determined and general assault, nor a passive investment with a minimum force. However, the Turks had learned their lesson and now adopted the second alternative, while they hurried the bulk of their forces towards Sannaiyat and Shaik Saad to resist General Aylmer.

Hitherto the struggle had been between the British and the Turks, but another combatant now entered the fray—the Tigris. Swollen by the rains in Kurdistan and Persia, the river overflowed its banks on January 21st, assailing both British and Turks with equal ferocity; and the torrential rain, which had fallen around Kut since the 8th January, helped that assault by turning the whole country into a morass. The floods burst into our front line trenches in the North-west Zone, forcing the men to retire to the Middle Line. The Turks opposite to them, up to their necks in water, had to evacuate their own trenches a few hours later, and a sheet of water nearly a mile wide separated the combatants in that area on January 23rd. The floods extended to Redoubt B, but, thence to the fort, the original

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front line could still be held. The photographic illustration, taken in April, 1916, from an aeroplane of the Relief Force shortly before the surrender, gives an idea of the extent of the flooded areas around Kut at that time, but they had then subsided considerably from the January level, *e.g.*, the swamped ground between the opposing lines near the Tigris in the North-west Zone appears as dry. From the middle of January every effort was made to save the Kut area from inundation, and large working parties of Arabs as well as troops were employed in throwing up miles of embankment to exclude the water. The Tigris soon became a greater immediate menace than the Turk, though the latter lurked behind the floods ready to take advantage of the work of his new and treacherous ally.

The progress of the Relief Force, in the operations undertaken to save Kut, was rather uncertain up to the middle of January. About that time, however, a wireless message arrived stating that General Aylmer's force, consisting of the 7th Meerut Division and other troops, had already attacked the Turks downstream of Shaik Saad and had captured their position, though they had lost 4,000 men in doing so. The heavy casualties in this battle, and the fact that the Turks had been sufficiently enterprising to occupy a position so far below Kut, gave food for serious reflection and caused some misgivings which we did our best to conceal. Another telegram stated that the 3rd Lahore Division from France "was nearing Basra," and we pondered on the significance of those last three words. However, we heard later that the Relief Force had turned the enemy out of a position east of the Wadi (upstream of Shaik Saad) on January 13th, and then that an assault on the Turkish trenches at Hannah (below Falahiyeh) had failed (see *Diagram* III). This attack took place in terrible weather over muddy ground on a very narrow front, so it is scarcely surprising that it met with little success. The Tigris and the adjacent marshes forced the British to attack frontally, and the space was so restricted that only a small number of men could advance to the assault. But in the operations ending with the failure at Hannah, the Relief Force had lost more than 8,000 men, and was thus brought to a standstill. This was a sad blow to the hopes of the Kut garrison, who now understood for the first time the quality and enterprise of the enemy, and the terrible natural obstacles created by the Tigris and the rain; so General Townshend, seeing that the rain, floods and bad news had damped the spirits of his men, issued a cheerful *communiqué* affirming his confident belief that Kut would be relieved during the first half of February. This pronouncement had the desired effect, and he continued to issue others from time to time throughout the siege; but the hopes raised by these *communiqués* were dashed to the ground each time, and the cheering news had less and less effect as the siege dragged its weary length, just as a drug loses its effect on a sick man. It seems to be a very open question whether the maintenance of morale by the issue of optimistic

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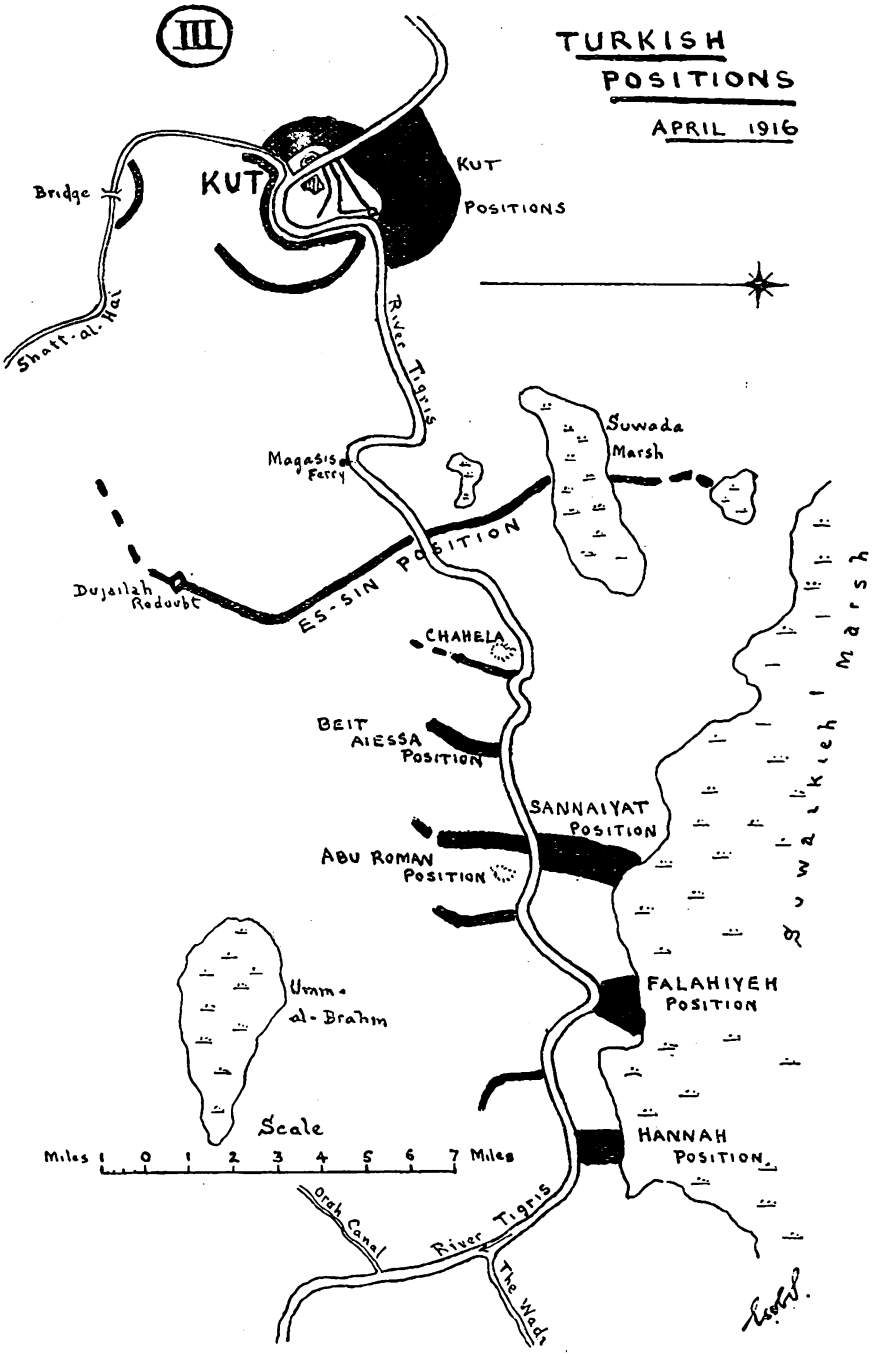


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reviews of the situation is advisable when that situation is obviously very grave. On the other hand, the policy of withholding information may lead to pessimistic conjectures which are bad for morale. Perhaps a bald statement of the true situation, coupled with *hopes* of ultimate victory, may be best.

The check at Hannah, which could only mean a much prolonged siege, concentrated the attention of the garrison on the matter of supplies. At the end of January, 1916, there began to be a scarcity of flour in Kut, though large amounts had been discovered in the town. Having already eaten most of the oxen of the Heavy Battery gun teams, the troops were then issued with horseflesh, but many of the Indians refused to touch it at first and consequently suffered much from hunger and weakness. Each British soldier, at that time, got 12 oz. of bread and 2 oz. of jam or butter daily, and, sugar being finished, was issued with 4 oz. of dates as a substitute. It was not till early in March that food became really scarce; the date supply was then exhausted, the ration of tea ceased, and even the jam ration was reduced to a mere taste and soon ended. After the failure of General Aylmer's attack on the 8th March, the bread ration was reduced to 10 oz., at the end of March to 8 oz., on April 12th to 6 oz., and on April 22nd to 4 oz.—a starvation ration indeed. Thus, to the bitterness of hope deferred, were added the gradually increasing pangs of hunger, and each reverse of the Relief Force, which was also on reduced rations, meant a further tightening of belts in Kut. The rations of the Indian troops dwindled equally with those of the British, yet, to the credit of all, each reduction was accepted as inevitable and was even made occasionally the subject of jest. There was always plenty of horseflesh, though it failed lamentably to satisfy bodies craving for cereals and sugar. Horses consume a vast amount of grain, and all the available grain was wanted for human consumption; therefore, not only were the horses slaughtered daily to provide meat rations for the troops, but four hundred were destroyed and buried, one day in March, merely to reduce the consumption of grain, and thus the bulk of our artillery had to be rendered immobile in order that the men might survive. Personally I found horseflesh rather sickly in flavour and preferred mule. *Mule's tongue in aspic* once graced the table of the R.E. Mess and was greatly appreciated! Roast donkey was said to be unpalatable, and none reached our mess, but I had the offer once of some camel stew made by my men and approached it with curiosity not unmixed with doubt—I left it hurriedly, and with no doubt at all. Towards the end of the siege, desperate attempts were made with three or four aeroplanes to provision Kut by dropping sacks of flour within the defended area, but, as the result of 11 days' flying, the machines only dropped enough flour to give a 4 oz. bread ration to the troops alone for four days, allowing nothing for the Arab population. The effort was therefore a failure, and hardly influenced the duration of the siege. As a

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forlorn hope a crew of volunteers in the river steamer *Julnar* attempted to run the gauntlet of the Turkish positions on April 25th with 270 tons of selected provisions for the Relief Force. Sad to relate, the ship was disabled and captured at Magasis, within sight of Kut, and thus it was decreed by fate that the garrison should perish by starvation, or surrender to the Turks and accept a destiny hardly less cruel.

The weather improved in the middle of February, and the spirits of the troops rose in consequence. The distant thunder of Aylmer's guns could be heard distinctly. On February 13th the first hostile aeroplane dropped into Kut several 30-lb. British bombs captured during the retreat from Ctesiphon, and arrangements were made at once to provide anti-aircraft defence as I have already related. During the next few weeks, the Turks bombed Kut frequently, sometimes with three aeroplanes, though they did comparatively little damage. Nevertheless, the effect on the Arab population was bad, and we were glad when the aeroplanes found more urgent work at Sannaiyat, Falahiyeh and Shaik Saad. The energies of the garrison were devoted during February to elaborate preparations for co-operation with the Relief Force when it had broken through the Turkish positions and reached the Tigris near Kut. A sympathetic wireless message arrived from His Majesty the King which put new heart into the men, and some newspapers, dropped from aeroplanes, showed that the predicament of Townshend's force was fully understood at last in England. The hospitals in Kut were overcrowded with sick as well as wounded, for scurvy and other diseases had appeared and claimed new victims every day from among the more debilitated. But those who were capable of work laboured with renewed vigour, and the preparations for attacking the enemy, when General Aylmer arrived on the scene, were soon complete.

General Townshend's alternative schemes for co-operation with the Relief Force, when it approached, were as follows :—

(*a*) To attack the Turkish camp on the left bank at Shumran upstream of Kut.

(*b*) To attack the Turks when they were retiring past Kut on the left bank after they had evacuated the Hannah position owing to the operations of the Relief Force.

(*c*) To evacuate Kut, crossing to the right bank with guns, ammunition, supplies, sick and wounded, while the Relief Force attacked and held the enemy.

(*d*) To reinforce the garrison of Woolpress Village on the right bank, and then to launch an attack from that village to facilitate the crossing of the Shatt-al-Hai Channel by the Relief Force.

(*e*) To cross the Tigris with a " Maximum Force " to co-operate with General Aylmer, while still holding Kut with a " Minimum Force."

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None of these schemes, however, could be put into action, because General Aylmer never came within sight, and I do not believe that Schemes (*c*), (*d*) and (*e*) were possible when he attacked in March, owing to the lack of boats in sufficiently good condition to transport large numbers of troops across the river. The schemes involved much work for the Sappers. The preparation of bridges to enable our guns to cross trenches, and the manufacture of trestles and decking for bridging the Shatt-al-Hai Channel, kept the men busy from dawn till sunset. An elaborate floating mine was also contrived with the idea of blowing up a Turkish floating bridge far down that channel (see *Diagram* III).

On February 22nd the whole garrison stood to arms throughout the day. It was the occasion of a surprise bombardment of the Turks in the Hannah position, whereby General Aylmer hoped that they might be induced to vacate their trenches and retire up the left bank. The enemy, at this time, had 10,000 men in that position, 8,000 at Es-Sin, and another 8,000 around Kut. General Townshend was requested by wireless to attack the Turks when they retired past Kut, *i.e.*, to put into operation his Scheme (*b*) ; but they, with their usual tenacity, refused to budge from their trenches at Hannah, and indeed, the British artillery bombardment, unsupported by infantry attack, was not such as to force seasoned troops to abandon their positions. Surprise bombardments of the same kind were tried on two or three occasions subsequently, but always without result. In a way they served to encourage the garrison in Kut, just as the sound of the picks of a rescue party may encourage entombed miners, though a reaction set in when the roar of the guns died away without news of any assault. Sweepstakes were arranged on the date on which the first of Aylmer's ships would pass the fort, and excitement grew daily as the time approached for the great attempt. At last it came, and on March 8th we stood to arms again throughout the day while our fate hung in the balance. We had launched the floating mine during the previous night, though it failed to reach its objective, and our guns fired on every target, regardless of ammunition, while daylight lasted. Every man knew his job and longed to do it, but was obliged instead to sit powerless in his trench, consumed with anxiety which increased as the hours wore on. From the house-tops in Kut we could see the British shrapnel bursting in salvos along the whole length of the Es-Sin position, only six miles away, and the roar of the bombardment was incessant. Turkish batteries galloped hither and thither on our side of the clouds of smoke, and columns of infantry hurried to the fight across the dusty plains. For several hours the din continued, became intense at sunset, died away during the night, and burst out again on March 9th, but not one soldier of the Relief Force did we see. Then there was silence, the troops returned to their billets, and, on the following day, we heard of the long night march from the Wadi, the bombard-

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ment of the empty Dujailah Redoubt at dawn, the failure of the infantry attacks on that redoubt when manned, and the precarious retreat to the Wadi. The blow was almost paralysing. Rain fell again in torrents, rations were reduced, and there were grim faces in Kut. In the minds of one and all was the well-night incredible fact that *Aylmer's attack had failed* and that no relief could be expected till many weeks of starvation had been endured.

In some of the officers' messes, the monotonous diet of horseflesh was much relieved for a time by the addition of roast starling when the few sportsmen who had shot-guns could sally forth into the palm groves outside the town. Starlings and sparrows clustered in hundreds on the palm fronds, but, as ammunition was very precious, it was no time for sporting shots at flying birds. I remember seeing a keen *shikari* waiting patiently under a branch till it was crowded from end to end with chirping birds. Slowly, slowly, he raised his gun, and with careful aim let fly so as to enfilade the line. A shower of starlings fell to earth, and, rather shamefacedly he put away his gun while his orderlies collected the dead and dying. He remarked to me that he knew it wasn't sport, but that he was hungry and there were many in his mess. I was hungry, too—painfully hungry—and the prospect of another horseflesh supper was nauseating ; so, when he had gone, I hunted around on the chance of picking up a sparrow or two, or perhaps even a stray starling ; but the Arabs had already searched the ground and there was not a feather to be seen, so I returned empty-handed through the evil-smelling streets.

Four days after the failure at the Dujailah Redoubt, General Gorringe, previously Chief of Staff, succeeded General Aylmer in command of the Relief Force. He proceeded at once to investigate the possibility of another attempt up the right bank, but decided that, as the country on that side could be flooded at will by the enemy, an advance up the left bank was more likely to succeed, though it would necessitate the deliberate frontal assault of position after position held in strength by the enemy. Accordingly he prepared to renew the attack on the Turkish position at Hannah on the left bank, where the 7th (Meerut) Division had already sapped up close to the hostile trenches. The 3rd (Lahore) Division was on the right bank, and General Gorringe brought up the 13th British Division to relieve the 7th Division and assault the Turkish position. He informed Townshend that the Kut force was " the rock on which he hoped to split the Turkish forces," and urged him to bombard the enemy's ferry at Magasis in the Es-Sin position and to contain the enemy on the left bank near Kut in the final stages of the operations, if successful. It appeared, therefore, that the open warfare of early March was to give place to a deliberate advance with limited objectives—in fact, to the type of warfare elaborated in France and Belgium. The dispositions of the enemy, and the condition of the ground, necessitated this change, but it was very doubtful if Kut could be

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reached by these methods before the garrison was forced to surrender from starvation.

By the middle of March, the network of Turkish redoubts, trenches and wire around us was practically complete, and the enemy still further reduced his containing force. Khalil Pasha affirmed, after the surrender, that at one time he had only 3,000 men in the trenches before Kut, and, considering the state of the ground and the strength of the Turkish positions, he probably spoke the truth. The river level was rising again. More and more ground was becoming flooded. The enemy's artillery and aeroplanes increased their activity as his troops moved downstream, and, from March 18th to March 23rd, there were heavy bombardments and aeroplane raids at intervals. But the Tigris then became so threatening that hostilities ceased, and both combatants fought the water instead. The flood culminated on March 26th, when Redoubts A and B were inundated and most of our trenches were impassable, as there were no " duck-boards." Kut town and the adjacent ground, protected by continuous embankments three feet high, were actually below water level for several days, and only the most constant inspection and repair of the earthwork saved us from disaster. The siege may be said to have ended with the advent of the great flood of March, 1916. The fate of the garrison was then sealed, though no one would have admitted it, whatever his misgivings. Kut then became merely a backwater of the torrent in Mesopotamia—a prize for the winner in the furious struggle below Sannaiyat.

General Gorringe, urged to premature action by the desperate circumstances, seized the opportunity of a break in the deluge of rain which had fallen early in April to launch his attack against the Hannah position. He wired at 8.0 a.m. on April 5th to say that he had captured five lines of trenches, and then there was silence. It appeared later that he captured the Abu Roman position on the right bank opposite Sannaiyat on April 6th, then the Falahiyeh position on the left bank upstream of Hannah, and entrenched close to the Sannaiyat position on April 8th (see *Diagram* III). But when, at dawn the next day, he attempted a surprise assault on that position, his troops were discovered as they staggered through the morass and were mown down by concentrated machine-gun fire. The attack failed with terrible loss, and the Relief Force was obliged to pause to receive reinforcements, which brought its total strength to 29,000 bayonets and 133 guns; but, meanwhile, the 3rd Division managed to take the Beit Aiessa position on the right bank, whence enfilade, and even reverse, fire, could be directed on the Sannaiyat trenches across the river. The 13th British Division then moved forward towards Chahela, threatening the left of the enemy around Beit Aiessa and overlooking his communication trenches on the other bank leading to the Sannaiyat position. It was altogether a very curious situation, the British on the right bank of the Tigris being almost in rear of the

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Turks grimly holding the Sannaiyat position on the left bank. General Gorringe made his last desperate effort on April 22nd, when his assault on the Sannaiyat position was again repulsed with very heavy loss. With that disaster, our last hope of relief vanished, though the gallant attempt to send food to Kut in the steamer *Julnar* on the 25th April might possibly have enabled the garrison to hold out for a few more weeks if it had succeeded; but I do not believe that, during that period, the Relief Force could have reached Kut, an opinion formed after a study of the resistance met by General Maude only a few months later.

There is little to write of the latter days of the siege itself. The usual routine continued, as far as the waning strength of the men would admit. The weather got warmer, and the stench of the streets and the bites of myriads of sandflies added new discomforts to the pangs of increasing hunger. The Arabs gave up hope and tried to leave the town. Every household was hard at work making rafts of tins on which to float down the river, and each night the rafts were launched from the river front; but the men, women and children on them were shot down by Turkish machine-guns below the fort as an example to deter the remainder. Hardly a soul escaped alive; yet, night by night, the Arabs went to their doom rather than trust to Turkish mercy after the surrender. On April 27th, a few days after the death or murder of Von der Goltz at Baghdad, an armistice was arranged at Kut. Two days later, General Townshend surrendered, and the Turks marched in past the fort.

Khalil Pasha did not capture a single British gun when his men entered Kut. Every gun and howitzer had been destroyed with guncotton, the motor boats sunk, the wireless apparatus burnt, the ammunition thrown into the river, and most of the rifles rendered useless. As for supplies, he was welcome to the sacks of ginger which revetted one of our paths, for that was about all we gave him! The 6th Indian Division and 30th Brigade had held out for 143 days—23 days longer than Ladysmith—and they were finally overwhelmed, not by the Turk, but by starvation and flood. They were never defeated in battle. The capture of Kut-el-Amarah was the last striking success achieved by Turkish arms during the Great War, and it was amply avenged by General Maude in 1917 and General Allenby in 1918. Its lessons are many—the danger of allowing investment under any circumstances, the risk of underestimating an enemy, the difficulties of calculating available supplies in a hostile land, and the disastrous effect of rain and floods—but, whatever errors may have been committed, whatever losses incurred, the defence of Kut and the valiant attempts of the Relief Force showed the grit and courage of the British soldier and his Indian comrade in arms, and thus they form together a page in the history of the Empire of which England need never be ashamed.

# *THE REORGANIZATION OF THE ENGINEERING TROOPS OF A CANADIAN DIVISION—GREAT WAR*, 1914–18.*

By MAJOR (Bt. COLONEL) H. F. H. HERTZBERG, C.M.G., D.S.O., M.C., *p.s.c.*, R.C.E.

(*Written in March*, 1920.)

PRIOR to the reorganization, which it is proposed to describe in this article, the engineering troops of a Canadian division in the field were as laid down in War Establishments for the Britannic Forces and consisted of the following units :—

(1) A Headquarters, Divisional Engineers.
4 officers, 20 other ranks, 15 horses.
(2) Three Field Companies (each).
6 officers, 210 other ranks, 73 horses, transport including pontoon equipment for 75 feet of medium bridge.
(3) A Pioneer Battalion.
30 officers, 1,000 other ranks, 54 horses.

A total force of 58 officers, 1,650 other ranks, and 303 horses.

After the reorganization each Canadian division was allotted an engineer brigade comprising :—

(1) A Brigade Headquarters.
4 officers, 22 other ranks, 9 horses.
(2) A Bridging Transport Unit.
3 officers, 66 other ranks, 73 horses, transport included pontoon equipment for 225 feet of medium bridge.
(3) Three Battalions (each).
37 officers, 969 other ranks, 148 horses, 8 lorries.

A total of 118 officers, 2,995 other ranks, 526 horses, and 24 lorries, besides one motor car, 3 box cars and other vehicles.

The decision to make this drastic change in this arm of the Service was finally taken at a very critical moment in the campaign—probably at the turning point of the War. The enemy offensive of the spring of 1918 had been to all appearances stopped ; but the Canadian Corps, although held in G.H.Q. reserve ready to be thrown into the most threatened part of the line should the enemy again attack, was, at the same time, undergoing a process of intensive

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training in open warfare preparatory to the Allies' offensive which commenced in July, 1918. To completely wipe out the old system, which had been functioning for some four years and in which officers and men were more or less experienced and trained, and to inaugurate an entirely new and untried organization at such a time was a big decision to take. The difficulties surrounding it and the risks which it entailed were only too well appreciated. On the other hand the advantages to be gained, if success was obtained, were many and important. The pros and cons were consequently very carefully considered, with the result that early in May, 1918, the reorganization was ordered to be proceeded with at once. Establishments were prepared, approved and issued ; the new units were formed on paper and, finally, the three field companies and pioneer battalion in the division of which the writer was C.R.E. at the time, were, on 7th June, 1918, marched on parade, disbanded, formed into the new units and marched off the parade as a brigade of engineers.

The primary reason for this reorganization may be stated, generally, in a sentence. A self-contained engineering organization was required that would be capable of not only supervision, as heretofore, but also of carrying out the actual construction of all engineering work. The necessity for such an organization became more and more pronounced as the character of the fighting changed ; more permanent and heavier defence works of all kinds were developed, deep dug-outs, subways, deep machine-gun emplacements, protection from air craft, defences in great depth, enormously increased tonnage of ammunition for guns and trench mortars entailing improved communications and increased transportation facilities such as tramlines and better roads ; all of which caused a corresponding increase in the duties and work of engineers to such an extent that the old system of sapper supervision and infantry labour was found utterly inadequate to cope with the new requirements.

It is proposed to deal with the details of the question as concisely as possible, under three main headings :—

(A) Defects in the old organization.
(B) Difficulties encountered in making the change.
(C) Results, after actual trial, of the new formation.

## (A)—Defects in the Old Organization.

The usual custom was for a field company to be allotted to an infantry brigade area, to be responsible for the work in that area both to the C.R.E. and to the infantry brigadier, thereby involving all the evils and confusion of dual control. Theoretically, the field company reported direct to the C.R.E. and was not under the orders of the brigadier but only attached to him to supervise the

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work in his brigade area; but, actually, the field company was in much closer touch in every way with the brigade than with the C.R.E.; it moved usually under brigade orders, received rations, etc., through the brigade supply officer, and was generally looked upon by the brigadier as one of his own units; the C.R.E., unless a very strong personality in the division and an exceptionally energetic man, was regarded too often as a far-away sort of person at division headquarters, to whom work reports were sent. The C.R.E., although nominally responsible for all defence works to the divisional commander, had usually the greatest difficulty in carrying out work in accordance with the divisional scheme, because each brigadier in his own sector of the line had his own special ideas on what work was required and how it should be done; which, after all, was natural enough in view of the fact that he was held responsible for the defence of that sector and his brigade was finding the labour to carry out the work. Confusion, lack of efficiency and waste of labour and material were the obvious results. For instance, one brigadier holds a section for eight days and commences work which he considers necessary, he is relieved by another brigadier at the end of that time who holds different opinions, the result being new work is commenced and the previous tour's work is left incomplete and of little or no value. The cause of this trouble was due mainly to the fact that field companies were too closely affiliated to brigades and that, as all labour was usually supplied by the brigade, the brigadier naturally felt that he should say how, when and where it should be used. Consequently it was a very difficult thing, indeed, to maintain the proper continuity of work during brigade reliefs.

The second and perhaps the greatest evil of the old system was the infantry working party—something despised and loathed by the infantry and, incidentally, not over loved by the sapper. The infantry claimed they came to war to fight, not to dig, and they did just as little of the latter as they possibly could, regarding it rather in the light of a degrading fatigue. The officer disliked it just as heartily as the man. He usually showed little or no interest in the work on hand and he felt no responsibility for its completion, apparently being under the impression that his duties ceased when his party was turned over to the engineer representative at the pre-arranged meeting point if, indeed, he had been so fortunate as to find it at anywhere near the appointed time; and that his services would not again be required until the time arrived to break off and take his party back to their lines. When, as a matter of fact, the duties of the engineers, properly speaking, consisted in laying out the work, allotting tasks and assisting in explaining what was required; the infantry officer was then responsible for his men doing the required amount of work and not leaving the job until their tasks had been completed satisfactorily; the motto being

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"engineers responsible for *quality* and infantry for *quantity*." Also, the engineers sometimes failed to supply tools or materials, or they arrived late and the infantry, who had perhaps been in the trenches all day, were forced to sit around and wait in rain and bad weather and probably under fire; again, the engineer officer was late or did not know his job, and consequently delay occurred and unnecessary work was done. These and many other incidents, too numerous to mention here, tended materially to interfere with the efficient carrying out of the work in hand. One of the greatest objections to infantry working parties must be noted before leaving the subject, namely, that it was rarely, if ever, possible to keep the same men, or even the same unit, on any one piece of work until its completion; attempts were continually made to turn over one trench or one piece of work to some definite company or platoon, to be its own particular little job to do as well as possible and as quickly as possible and, as their work was well or poorly done, so they would deserve praise or censure. If this could have been arranged the men would have become familiar with the work, guides would not have been required and parties would not have so frequently gone astray and missed the meeting places, etc.; and some interest and keenness might, perhaps, have been created in the work.

The third important defect in the field company organization had to do with the R.E. park, workshops and the transporting of material. No establishment whatever was provided for personnel to operate divisional parks and workshops and, as these were, of course, essential, the necessary men had to be attached from field companies and infantry brigades, which was decidedly objectionable from the standpoint of those units. As regards transport for engineer material, there was none; field companies had only sufficient transport for their own permanent equipment; so that all sorts and conditions of wagons were used for this purpose; pontoon and trestle equipment of field companies was, when possible, off-loaded and parked and the wagons used for carrying timber and every imaginable class of R.E. material from the R.E. parks to forward dumps. G.S. wagons and forage carts were also obtained from infantry brigades for work only in that brigade's area. This transport was not sufficient and finally lorries were obtained daily from the corps when they would be spared, which was not always by any means, and the whole system of transporting engineering material was most unsatisfactory.

Another objection to the old organization was the great difficulty in relieving field companies and bringing them out of the line for purposes of training, refitting and rest. This was found, with very few exceptions, to be impossible; the amount of work was so large, the personnel to do it so limited, that field companies were frequently

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left on front line work for months, night in and night out with no relief whatever, except what could be arranged by sections in the unit itself. Apart from the hardship to officers and men, the lack of training was seriously felt, especially as drafts came from England containing men who could hardly be termed soldiers, and certainly not trained sappers, capable of supervising the rather complicated construction of, say, a deep dug-out or other work requiring technical knowledge.

And now a word about the pioneers who were very welcome when they finally arrived. A battalion was assigned to each division, reporting to the C.R.E. as regards work, but administered by the division—again the dual control and all the troubles connected with it. However, the pioneers proved very useful indeed. The writer found they worked most satisfactorily when given certain definite work to do—a long communication trench, a redoubt, a scheme of wiring, etc.—where it was possible to keep a company on the same job until it was completed so that no labour or material was wasted due to that lack of continuity and change of personnel, which, with the infantry working parties, was so prevalent. The pioneers, however, were not trained sappers, nor were their officers, with few exceptions, engineers ; so that usually engineer supervision was still required.

### (B)—Difficulties Encountered in Making the Change.

For the formation of each engineer brigade the following units were available in each division :—

(1) H.Q. Divisional Engineers,
(2) Three Field Companies,
(3) One Pioneer Battalion,

while the technically trained and experienced tunnelling personnel required in each brigade were to be found from the tunnelling companies heretofore employed directly under the Chief Engineer of the corps. The brigades were then to be completed and brought up to strength as far as possible in officers and men by drawing on the training depôt in France and the reserve depôt in England.

The existing headquarters, divisional engineers, formed the foundation for the headquarters of the brigade. The three field companies formed respectively the nuclei of the three battalions. The headquarters and three of the four sections of each field company serving as a basis for the headquarters and three of the four companies of each battalion ; the fourth section of each field company being equally divided into three parts, each part being allotted to one of the other three sections ; the intention being to form the fourth company of each battalion from the tunnellers, which was duly carried out some two weeks after the brigades came into existence.

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The engineers and tunnellers therefore, as above described, were equally distributed in each battalion and formed the technically trained portion of it. The pioneer battalion was then divided into three equal parts and one part allotted to each battalion as the untrained or labour portion; the remaining deficiencies in the strength of each battalion were then made up from the depôts as far as men were available. Some officers and other ranks of the infantry with engineer training and experience were interviewed with a view to their transferring to the sappers, but very few men were obtained in this way. As regards transport; the field company and pioneer transport, less bridging equipment, was divided equally among the three battalions, while the pontoon and trestle wagons with equipment and horses were taken from the field companies and formed the divisional bridging transport unit.

There were numerous objections to, and difficulties encountered in, the process of reorganization as above outlined. In the first place, there was by no means a sufficiency of officers and men to complete the units as authorized by establishment and, at first, a battalion totalled about 17 officers and 650 other ranks; this was, however, gradually increased until a battalion reached approximately 30 officers and 800 other ranks. The same remarks, as to proportion and gradual increase, may be made regarding the transport, including horses, vehicles and mechanical transport. The delay in supplying the requisite additional transport was largely due to the fact that the British Government was at that time supplying transport for the new American divisions to a very considerable extent.

In the second place, very strong representation was made by the pioneers against the breaking up of their units with the inevitable loss of their identity, etc., and this was only finally agreed to on the understanding that officers and N.C.O.'s of the pioneers should be absorbed by the sappers with their existing rank and seniority. This, in a way, was only fair and equitable from the pioneers' standpoint; nevertheless, the arrangement led to serious difficulty later on, and, naturally, gave rise to strong objections on the part of the junior engineer officers and N.C.O.'s who, in spite of the fact that they were trained and experienced engineers, were forced to serve under men who knew very little about such work. Also, in many cases, officers and men from the pioneers, through no fault of their's but simply due to lack of training and experience, were called upon to perform duties and assume responsibilities which, in all fairness to themselves and for the general good of the Service, they should not have been called upon to undertake.

Another criticism, and a very fair and reasonable one, was encountered from certain quarters representing the more senior Royal Engineer officer; and this officer had strong arguments in his favour, supported by his own long service and extended experience

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as well as by the wonderful record and glorious traditions of the Corps of Royal Engineers. He disliked very much the idea of his technically trained sappers being contained in the same unit with his unskilled labour; it had too much the appearance of a labour battalion. He considered further, and his point is well taken, that the percentage of the sappers to the infantry in a division would be too high. He also considered the new battalion too large a unit to employ on some special detached duty, such as with an infantry brigade on advanced or rear guard; this objection is not so well taken because the battalion was so organized that each company, or even section, was a self-contained unit with its own transport, including tool cart (bridging equipment as required could be attached from the bridging transport unit), and was therefore just as easily detached as the old field company.

There were, of course, in addition to those already quoted, other objections, both varied and numerous, which cannot be included here. Perhaps the most important of all is that which has been referred to in a previous paragraph, namely, the very critical stage in the operations of the campaign in which the change was made, and not the least danger in this connection was the tremendous risk taken in breaking up the organization of the tunnelling companies. It was because of this danger that all tunnellers were kept together in "D" Company of each battalion so that, if the new system had failed as regards tunnelling operations, it was a comparatively simple matter to reform the old tunnelling companies with the same personnel as before without delay and without upsetting, to any appreciable degree, the organization of the new battalions.

### (C)—Results after Actual Trial of the New Formation.

The new organization received its first test in August, 1918, in the Battle of Amiens. The results are known. They left no doubt as to the success of the new machine and, through the following hundred days' fighting which terminated in the capture of Mons, its efficiency and value were proved beyond all question. It was found that the long-desired self-contained engineering organization had been obtained. Infantry working parties were things of the past except for hasty consolidation, maintenance of their own front line system and other similar work which required no technical supervision. Work was accomplished in less than half the time required under the old system, because divisional areas were divided so that an engineer battalion had charge of each, remaining in that area directly under the orders of the C.R.E. irrespective of reliefs of infantry brigades; hence continuity of the work was maintained—the same men on the same job until it was finished. In the advance on Cambrai and Mons, all work in connection with roads and bridging

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was under the C.R.E. and carried out in accordance with a pre-arranged scheme, usually prepared by the Chief Engineer at the corps, so that absolute co-ordination of the work resulted. When required, each infantry brigadier was given a company from an engineer battalion to assist him in any way he wished, this company working directly under his orders, so that he was just as well off under the new system as when he had an affiliated field company under the old system.

The creation of the bridging transport unit was particularly suitable to the new conditions. Under the old system all the bridging equipment of the division was distributed equally to the three field companies, with the result that the company which happened to be employed on bridging operation usually found its 75 feet of medium bridge insufficient for its requirements. On the other hand the remaining two companies, probably detailed for work on defences and roads, had no use for this equipment, which was consequently lying idle when it was urgently required by the first company to complete their bridges. This difficulty disappeared with the advent of the bridging transport unit. This unit contained all the bridging equipment of the division and was so organized that the pontoons or trestles required for any operation might be attached temporarily to the battalion in charge of that work. Again, when the division was holding a front in which no bridging was required, its B.T.U. could be detached intact and placed at the disposal of another division where operations demanding such equipment were in progress.

Another function of the B.T.U. was to form the divisional R.E. park and workshop, its establishment in personnel providing the various trades necessary for this purpose. The pontoon and trestle wagons of this unit were available as transport for material by off-loading their equipment when it was not required.

At corps headquarters the new engineer M.T. company formed a pool of lorries under the direct orders of the Chief Engineer. This company was so organized that a section could be detached and placed under the orders of the C.R.E. of a division when advisable. In this way the great problem of transporting engineer material under the old system was solved; it was no longer necessary to beg, borrow or steal lorries from the M.T. column or horse transport from infantry brigades.

An important departure from the usual method of carrying out engineer services and controlling engineer personnel was made during the advance from Arras to Mons. This new method had been tried with success in the Somme operations under the old field company system; the adaptability of the new organization was such that even greater success was attained in employing this new method in the advance above mentioned. The departure referred to con-

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sisted in all divisional engineers being pooled under the direct executive command of the Chief Engineer Canadian Corps, who became the G.O.C. Canadian Engineers. The corps area was then divided into four more or less equal parts, two forward (A and B) and two rear (C and D), conforming to the four divisions in the corps. A brigade of engineers was then made responsible for each area irrespective of what division happened to be holding it. A and B Brigades in the two forward areas being employed on hasty repairs to roads and bridges, reconnaissance and preparation of crossings for infantry, guns and light transport; they advanced as the line moved forward until a pre-arranged objective was reached when A and B Brigades would be leap-frogged by C and D. The two latter brigades would continue the advance while the two former remained in their present respective areas improving roads and constructing heavy bridges capable of carrying all transport, including tanks, and taking over and organizing captured R.E. parks, water systems, etc.; and, when their work was finished, the leap-frogging process of the two forward brigades again took place. The advantageous results from this method of working are obvious—the same men on the same job until its completion, continuity maintained and no waste of labour or material, a pre-arranged plan definitely followed and always under the one responsible head with no detrimental effects of dual control, each brigade alternately employed on front line and rear area work and, finally, change and relief for officers and men.

In conclusion it may be stated that, in February, 1919, the question of the reorganization of divisional engineers came before the War Office Committee sitting on the Re-establishment of the *post-bellum* Division of the British Army in the Field. At that time the Canadian organization received the very careful consideration of the Committee and it is understood that in their final report they recommended the adoption, in a modified form, of an organization more or less similar to that discussed in this paper.

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# *THE USE OF INVENTIONS IN WAR.*

*By* CAPT. AND BT. MAJOR G. LE Q. MARTEL, D.S.O., M.C., *p.s.c.*, R.E.

A POINT that is often raised in discussion is the question as to whether it is possible to gain a great victory by the use, as a surprise, of some invention. Doubt is not usually expressed as regards the possibility of effecting surprise, but as regards the effectiveness of an invention which has not been tested in war. For instance, the statement has often been made that the tanks in the Great War were not really effective until they had been tested and altered as the result of trial in war. It is then given as a considered opinion that a " Cambrai " battle, on a wide front, with tanks, could not have been successfully launched in 1916 before the tanks had undergone a trial in war. It may be true that such an attack could not have been launched, but the reason given is totally wrong. It is a matter of fact that the tanks used at Cambrai were for all practical purposes the same mechanically as the Mark I tank used in September, 1916. It is true that the rollers had been strengthened to stand the pavé roads in France, and the steering wheels in rear had been abandoned as not worth the bother of fitting, but these were minor alterations, and were not improvements due to the test of war.

The difficulty of launching a surprise tank attack in 1916 was not due to any mechanical weakness, but was a matter of psychology. The senior officers in the Army at that time were lacking in modern engineering or mechanical knowledge. They looked with suspicion on this new mechanical weapon, and although they were very anxious to use this weapon as an auxiliary to help the infantry in any possible way, yet they would have opposed the idea of using the tank instead of preliminary artillery bombardment to enable the infantry to cross the wire entanglements. Even in 1917 at Cambrai one senior officer declared that his infantry were about to be murdered by this idea of using tanks instead of a preliminary bombardment. Other than this there is no reason why tanks should not have been used in 1916 on a wide front in a surprise attack and to lead the infantry to a decisive success.

And so it is with all inventions. Given leaders with modern ideas and ready to employ new methods under modern conditions, there is no reason whatsoever why an invention prepared in peace time or in war should not be launched on a large scale against the enemy and effect decisive results, provided the element of secrecy can be maintained. That secrecy can be maintained has been shown repeatedly,

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*vide* the use of gas by the Germans and the employment of tanks (though on a very small scale) by ourselves in 1917.

If we are agreed that an invention can produce decisive results, then inventions are one of the most important considerations in any army. The difficulty, however, does not lie so much with the production of the invention as with knowing what to invent, as the following instance will show.

Before the Great War Colonel J. F. C. Fuller predicted that in the next war there would be long lines of trenches protected by barbed wire, and that the main problem would be how to attack the machine-guns behind this barbed wire. General E. D. Swinton laid emphasis on much the same point in lectures to cadets at Woolwich. If, now, some branch of the General Staff had been given the task of enunciating what would be the main problems of the next war, there is more than a chance that they would have come to the conclusion that Colonel Fuller and General Swinton were right, as indeed they were. This work of discovering what are the main problems of the next war is entirely a soldier's duty; it is the prelude to all inventions and the development of such inventions. Unless these ideas have been worked out and unless the Staff have a clear idea in their minds as to what will constitute the main problems of the next war, many opportunities will be missed. For instance, some inventors in 1908, working on the idea that the main problem of the next war would be how to attack the man in a trench behind barbed wire, produced a tractor which was very similar to the war tank. The possibilities of this tractor were demonstrated at Aldershot, but, as the Staff had not cleared their minds as to whether this was or was not likely to be a main problem in the next war, they took no interest in the trials, and the experiments were dropped.

We have, therefore, arrived at this position, that the General Staff must decide in their minds what are likely to be the main problems of the next war. Some of these problems are obvious, such as the desirability of inventing some means of bringing down an aeroplane, but most of these problems are much less obvious. Several problems suggest themselves, but much work is required to be done in sorting them out and discovering which are the most likely problems of the next war. Having decided on one or more as the most likely problems of the next war, the work of invention can begin in secret, and there is then a fair chance of an early and decisive success in war.

Having agreed that a new and secret invention may give decisive results in war without the publicity which is unavoidable with war tests, we can now discuss the best methods of developing an invention. There have been many inventions of war in the past; some of these, such as the invention of the gun, were developed so slowly that secrecy was out of the question. Others, such as gas and tanks, were developed more rapidly, and might have given decisive results if the

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soldiers had not insisted on the war test. But in no case has the invention been developed as rapidly as it might have been, and this is important, because rapid development is a great assistance to secrecy, and surprise depends on secrecy. Development has, of course, always been opposed by the Tories and by financial stringency; these are inevitable obstacles. But it is equally true that the development has in many cases been guided by men who had no experience in such work and the progress was consequently retarded. In this we have an obstacle which we can overcome comparatively easily. It is, therefore, proposed to discuss briefly the steps through which an invention has to pass from the original idea until it reaches practical realization. Lack of knowledge of this process has been the main cause of delay in the development of nearly every invention.

It is not only in the development of a new invention that we want rapid progress. A new invention may produce far-reaching results, but modern weapons which are slightly ahead all round of those possessed by the enemy are bound to produce a very substantial advantage. The development of new inventions and the improvement of existing arms and equipment go side by side. It is only possible in peace to re-arm an Army at fairly long intervals, owing to the expense involved, but this does not prevent the development of improved arms and the construction of nothing but the very latest pattern in the event of war. This means a great deal of careful work and trial in peace time, so that the best type and model of every arm is ready and can be handed over to mass production the moment that war is imminent. The following paragraphs, therefore, apply equally to the development of new inventions or the production of improved models of existing arms and equipment. Both are of great importance in the event of war.

Every invention passes through four stages in the progress to practical reality. These stages are :—

(i) The stage of pure research.
(ii) The stage of applied research.
(iii) The design stage.
(iv) The production stage.

We will take these stages in turn and examine them in some detail.

*Pure research.*—Pure research is the seeking after knowledge without having any definite invention in mind. For instance, the discovery of Hertzian waves was the result of pure research carried out by Professor Hertz, and this discovery led to the invention of wireless telegraphy, but Hertz had no idea of inventing a method of telegraphy when he carried out his work of research. As a rule the work of pure research has little to do with the soldier ; the work is much best left to civilian bodies, such as the National Physical Laboratory. The result of their work is always available if it should have

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any military application. In the case of inventions for war the General Staff must set the problem, and the inventor then seeks among the results of pure research to find something which may lead him to his invention. For instance, 50 years ago the soldier might have stated that one of his main problems was to find a means of communication between two headquarters which could not be connected by wire or visual signalling. The inventor should then have searched among the results of pure research and the Hertzian waves might have suggested to him a solution to the problem. As it happened, in this case the solution to this problem was equally important for commercial purposes, and so the invention was developed by civilian resources, but this is by no means always the case. As far as pure research is concerned, therefore, our duty is to watch the results and see if they may lead to some invention which may have a military application.

*Applied Research.*—Applied research is the development of a particular invention, but without making that invention conform to any specification. For instance, about 100 years ago the possibility of obtaining mechanical power by the use of some form of gas engine began to be realized. The possibilities were obvious. Light and economic engines were required for the propulsion of road vehicles and small boats, and engines which could be heavier and more bulky were required for stationary work. But at this stage it would have been quite premature to enter the design stage and endeavour to construct an engine to suit any one particular class of work. What was required was a period of applied research : no one had any idea at that time as to what sort of oil to use or the best way of producing the gas ; nor had they any idea as to whether the mixture should be compressed or burnt at atmospheric pressure. The designers had no data, and applied research was therefore necessary. One of the earliest attempts was an engine which sucked in an explosive mixture at atmospheric pressure and the mixture was exploded half way down the stroke. The experimental engine worked fairly well, and a company was formed to produce stationary engines working on this principle. We now know that the principle was entirely wrong ; none of the obvious alternative methods had yet been tried (such as compressing the mixture) ; and it was altogether premature to enter the design stage. The company went bankrupt. This was a very good example of the danger of entering the design stage when insufficient knowledge has been obtained from applied research. After this failure the necessary research work was carried out. In 1862 the Otto cycle was suggested, and later some experimental work was carried out on these lines. By 1876 nearly all the various alternatives had been tried, and a great deal of knowledge had been obtained. It was now possible to enter the design stage with a fair chance of success. Various designs were prepared for car engines, and station-

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ary engines, etc., based on the knowledge provided by research work, and these designs were now successful. But the same success would have been reached far more rapidly if all the available energy and money had been spent on research in the first place.

There are plenty of modern examples of the above mistake. For instance, in 1918 it was desired to construct a tank that was very fast and could swim across rivers and cross wide trenches. A tank of this nature was a totally different proposition to the construction of any type of tank or tractor that was known. No one had any idea as to the best type of track or transmission to use, nor how to steer such a tank. What was required was a period of applied research to provide some data. But, owing to war pressure, an attempt at design was made after a few preliminary trials. The tank was made, and gave some startling results, but proved in the end to be a failure. It contained some wrong principles for a tank of this nature. Then came the peace, and the mistakes should have been realized. Two or three years of applied research would have shown us how to overcome the difficulties, and we should by now have been in a position to design a tank to fill this specification. As it is, the whole of this time was lost. It is true that a very useful tank, constructed on the lines of the war tank, has been produced, but this comes nowhere near to the specification that we require, and it is impossible to construct a tank on these lines that will do so. We could have designed a tank such as the present new tank four years ago, and in the meantime we should have been carrying out applied research to give us the necessary data for designing a far better tank.

*The Design Stage.*—When sufficient knowledge has been collected, the design stage starts. It is impossible to lay down a definite line between applied research and design, but when we come to the next stage there is a very definite dividing line. It is even desirable to have design and production controlled by two separate branches so as to accentuate the division. When the design has been completed on paper, the munition of war, or whatever the article may be, must be constructed exactly as designed and thoroughly tested under conditions as near to war conditions as possible. This must be completed before production is started. It is an axiom that any new munition which has been designed will produce certain troubles which will require to be put right. It may be that the article is not suitable in some detail for the use by the troops; or it may show excessive wear on some part, or an unexpected stress on some portion of a mechanism, but it is a practical certainty that a new design will require at least minor alterations as the result of trials. Just as a child has to go through measles and chicken pox and other minor ailments before reaching manhood, so a machine usually has many minor troubles before reaching a stage where it is fit for production. The importance of allowing plenty of time for trials cannot be overstressed.

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The cases where great delay has occurred owing to undue haste in these trials are too numerous to mention. If production has been started and some trouble then arises during a trial, the difficulties of curing the trouble may be very great. The engineering industry of this country still laments the great loss in output of munitions dur ng the Great War occasioned by lack of thoroughness during the[1] design stage. Even a minor alteration in design must be most thoroughly tested before instructions are given for this cha nge to be incorporated in the next order for production machines.

*The Production Stage.*—Lastly, when every detail has been tried and tested, the munition of war goes into production. Only for strong military reasons should any alteration be made to the design after production has started. The most important point as regards production is that every part of the munition can, as far as possible, be made by " mass production." Semi-skilled labour is the order of the day during war, and semi-skilled labour means mass production or nothing. Before the war the difficulty of production was never considered. A munition, such as a gun, was altered and altered so as to produce the best possible gun without a thought being given to production on a large scale in war. During peace time there is plenty of skilled labour and it does not matter how complicated the parts of a gun may be, there will always be sufficient skilled labour to produce the small demands of peace conditions. The result is that during peace time munitions tend to become unsuitable for mass production. This is a great danger, for it means redesigning many parts on the outbreak of a great war. In 1914 the engineering industry was aghast at some of the things which they were asked to manufacture. " Why make them like this? " was their cry. And the answer was that they had " grown " like that as the result of numerous alterations to try and get a perfect weapon. Even if the weapon is not quite so perfect, it is better to have a weapon which can at once be made by mass production, than a weapon in which many parts have to be redesigned for mass production in the event of a great war. Even to-day, though it is only six years since the end of the war, complicated parts are beginning to creep into our munitions ; there are pieces of steel which are " cut out like cheese " in some weapons. This does not matter at present, for we are only likely to be engaged in small wars where mass production does not arise, but these points should be closely watched in the future. To do so, it is necessary to have experienced engineers on the design side, and this point is often forgotten. The design branch and the production branch should be quite separate, but close liaison is necessary to ensure ease of production. If the officers in charge are just " good sound men " with a smattering of scientific knowledge, as they are apt to be, these points are bound to be missed.

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To sum up, therefore, the following are the main points to ensure success :—

(i) The General Staff must enunciate the main problems of the next war.

(ii) An experimental and design branch must then suggest methods of meeting these problems. The necessary research work must be carried out and then the designs prepared. This must be followed by thorough tests and trials. This branch should work direct under the General Staff, and should be quite separate from any department charged with the responsibility for the production of munitions of war. To carry out this work, the officers must be qualified scientists, electricians or engineers, depending on the type of work with which they are dealing. The necessary secrecy must be maintained.

(iii) The department charged with the production of munitions of war, must be prepared to produce the designs evolved by the above branch in the requisite numbers and within the requisite time for war.

(iv) Given the above conditions, there is no reason why Great Britain, possessing as she does a great quantity of inventive genius, should not achieve a decisive victory at an early stage in the next great war.

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# *THE EARLY YEARS OF THE ORDNANCE SURVEY.*

*(Continued.)*

## IV. The Directorate of William Mudge.

**William Mudge.**—William Mudge was officially superintendent of the Ordnance Survey for 22 years; and even before he was formally in charge there is reason to suppose that he did, as a fact, have a principal share in the direction of the operations of the Survey from the year of its foundation in 1791; for Colonel Williams, the nominal Director, took little or no part in the work. We must picture quite a small department, almost too small to be called a department, consisting, as it did, of two officers and Mr. Dalby or Mr. Woolcot, a working party of artillerymen, a few surveyors and draughtsmen from the Ordnance, and one or two engravers. During Mudge's lifetime the object of the Survey remained the production of a one-inch map of Great Britain. Ireland was not originally included in its scope, and large-scale maps had not yet been thought of.

William Mudge was born at Plymouth on December 1st, 1762. His father was Dr. John Mudge, F.R.S., a celebrated physician, the friend of Dr. Johnson and of Sir Joshua Reynolds, both of whom held Dr. Mudge in high esteem. Dr. Johnson was William's godfather. Dr. John Mudge's father was the celebrated divine, Zachariah Mudge, Vicar of St. Andrew's, Plymouth, who was born in 1694. Dr. Mudge relates that when the news of Wolfe's victory at Quebec arrived he hastened to his father (Zachariah) with the Gazette; on hearing the news his father said, "Son, son, it will do very well, whilst the Americans have the sea on one side and the French on the other; but take away the French, and they will not want our protection." He saw clearly, at the moment, in the capture of Quebec, the expulsion of the French from Canada, and the consequent independence of America."* William Mudge was sent to the Military Academy at Woolwich in 1777, and while he was there he was visited by Dr. Johnson, who gave him a guinea and a book.† "Of his time at Woolwich Dr. Hutton said he was a sharp boy, but not particularly attentive. There were at that time . . . two Academies, the Senior and the Junior; over

* *Memoirs of the Mudge Family.* S. R. Flint.

† *Memoirs of the Mudge Family.* S.R. Flint—Truro. Netherton and Worth. 1883. From this book much of what follows is taken.

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the first Dr. Hutton presided, and in the Junior a Mr. Charles Green, who was rather remarkable for his slowness in teaching." In 1779 Mudge got his commission as a 2nd Lieutenant in the Royal Artillery, " and was sent out almost immediately to South Carolina where he served in Lord Cornwallis's Army. During this time there is mention made in his father's pocket-book of his writing home from Charlestown." He was promoted 1st Lieutenant in 1781.

On his return from America he was posted to duty in the Tower, and whilst he was there he commenced the serious study of mathematics, being partly moved thereto by the example of his brother officer, Shrapnel. He was helped in his studies by Dr. Hutton, who was thus very well able to judge of his abilities. In 1791, on Dr. Hutton's recommendation, Mudge was appointed to serve under Colonel Williams, who was put in charge of the Survey by the Duke of Richmond. In 1798 Colonel Williams died; his death removed an incubus that might have been fatal to the Survey. Mudge's ability and his experience of the work marked him out as the man to succeed, and he was directed to take charge of the Survey by the following minute :—

" Sir,

I have the commands of the Master-General to acquaint you that, sensible of the zeal and ability you have shown in that part of the Trigonometrical Survey, which it has fallen to your lot to execute on the death of Lieut.-Col. Williams, it was his Lordship's intention to have intrusted to you the conduct of its continuation; and it is with additional satisfaction and confidence that Lord Cornwallis now appoints you to that situation, assured of its coinciding with the wishes of his Grace the Duke of Richmond.

His Lordship desires that you will accordingly take on yourself the charge, as it has hitherto been held by Colonel Williams.

I have the honour to be,

" R. APSLEY."

Although R. Apsley wrote officialese, his meaning is clear enough, and Mudge now became Superintendent of the Survey, and remained in that office until his death.

In the same year, 1798, he was elected a Fellow of the Royal Society; the President, Sir Joseph Banks, informing him that the Fellows " were well aware of the zeal, diligence and ability he had shown in executing the interesting duty in which he was engaged." From 1798 to 1808, Mudge lived at the Tower; in the latter year he bought No. 4, Holles Street, which was his home for the rest of his life.

In 1809 he was unexpectedly appointed Lieutenant-Governor of the Military Academy at Woolwich; but he did not give up the direction of the Survey. " He found the Academy, as he said, in

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ruins; to remedy the state of things he at once struck at the root of the evil, and set to work to bring about better discipline, and management, among the Cadets." The appointment was made by Lord Chatham, who, in a letter to Mudge, written in 1817, expresses, not only his high satisfaction at the success with which his Survey continued to be executed, but added that it was "no less gratifying to him to learn that the Royal Military Academy has so fully answered all that was expected from it, and that it has attained that degree of perfection, the accomplishment of which was, he was confident, best insured when it was placed under Colonel Mudge's auspices."

But yet another duty was to be entrusted to this indispensable officer. Since 1798 the cadets for the Artillery and Engineers of the East India Company's service had been trained at the R.M.A., Woolwich. But in 1810 the Company established its own college at Addiscombe, the cadets in question being moved from Woolwich. Colonel Mudge was asked to superintend this new College, in addition to his existing duties. Small wonder that in 1811 we find him writing, "My labours are great and I am without strength to carry my chains. I can assure you that I am a slave, and not wearing golden chains." And again, "I have more business on my hands than I have strength for, or, if I had strength, even time to perform, and this has always been the case." What with his duties at the Tower and in the field superintendence of the Survey, what with his work as Lieutenant-Governor of the Academy at Woolwich, and as Superintendent of his College at Addiscombe, he could have been very little at Holles Street. And it would appear, also, as certain that, in spite of his capacity and energy, the work of the Survey must have suffered but for one fact; and that is, that he had, in 1802, selected, as his chief personal assistant in the direction of the Survey, an officer who was destined to impress his mark very deeply upon that institution, and whose zeal and ability equalled his own—namely, Thomas Colby.

In the summer of 1819 Mudge was promoted Major-General. Early in January, 1820, he was laid up at Addiscombe with some internal complaint. He returned to Holles Street and got better, but had a relapse, rapidly became worse, and died on the 17th April, 1820, in his 58th year. He had married the daughter of Major-General Williamson, R.A., and had five children—one daughter and four sons—two of whom became officers in the R.E., one in the R.A. and one in the Navy. He was noted as a man of great amiability of disposition and evenness of temper; devoted to his family; an excellent chief, kind and considerate; upright and scrupulously attentive to the public interest.

It may, perhaps, be appropriately mentioned here that there is a letter in the Colby collection, written to Colby by Isaac Dalby (then an old man), which confirms the suggestions made above as

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to the inefficiency of the first superintendent of the Survey. The letter is as follows :

Farnham.
February 5th, 1821.

" Dear Sir,

I should have acknowledged your letter sooner, but am so much plagued with age and the rheumatism that I feel it very tiresome either to think or write : for the latter disorder the Doctor prescribes flannel and patience ; but I derive little benefit from following his advice—age, indeed, is a growing complaint ; and except one could get a dip in Medea's kettle there is no chance of getting rid of it.

You learn from the publications that I was a fellow labourer, from 1791 to the autumn of 1799, with our late worthy and much lamented scientific friend [Mudge] ; who always was zealous, active, and indefatigable in carrying on the Survey. Independent of his exertions, however, and prominent services in the undertaking, I do not recollect a circumstance derogatory to his character as a gentleman.—But truth compels me to drop eulogy in noticing our colleague Col. W[illiams] who nominally was the principal ; I say *nominally*, because he never made an observation, or calculation, nor did he write a line of any of the printed accounts ; in fact, he proved a dead weight in the undertaking by frequently retarding its progress : and the only time he benefited the service, was when he took his departure to the next world.

I have yet to learn what disorder was the immediate cause of the General's death. I know he had sometimes been subject to the *hyp*, or something like it ; particularly when we were measuring the base on Sedgemoor : at that time he often complained of *depression of spirits*, but found relief from exercise on horseback. It was rather singular, however, that he always got into the most unfrequented parts of the country in his equestrian excursions.

Our routine of proceedings year after year had so much sameness, that I think you may collect what is necessary from the printed Accounts, and more to the purpose than I could furnish from recollection, after a lapse of more than twenty years, at my time of life ; for I now find myself much more dexterous at forgetting than in remembering."

It is, therefore, clear that Mudge was in effective control of the Survey—that is, so far as Williams did not put difficulties in the way—from 1791 to the date of Williams's death in 1798. From that date, until his own death in 1820, Mudge was officially and actually in charge of the Survey. From 1809 he was also Lieut.-Governor of the R.M.A., Woolwich, and from 1810 he was, in addition, Superintendent of the H.E.I.C.'s College at Addiscombe. From the nature of the case, after his assumption of these other duties, much of the direction of the Survey fell into the very capable hands of his friend and junior colleague, Thomas Colby. There is no doubt that the arrangement worked well, as it was bound to with two such reasonable and clever men as Mudge and Colby.

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**Work in 1799.**—One of the first things that Mudge did, after assuming charge of the Survey, was to ask the Royal Society to lend Roy's 3-ft. theodolite. He says that "in very early stages of the work I had frequent opportunities of observing, that eminent advantages would accrue to the service, were the survey prosecuted on a more extensive scale. The consideration of a grand instrument being laid up in the apartments of the Royal Society suggested the propriety of obtaining it; therefore, when my appointment to my present situation gave me the means of effecting former ideas, I lost no time in applying to the President and Council for the loan of their large theodolite." (Probably Williams had vetoed the idea.)

The Royal Society readily granted Mudge's request and the instrument was put into Ramsden's hands early in January, 1799, for the purpose of having new microscopes fixed to it. Ramsden was also asked to complete the zenith sector which had been ordered by the Duke of Richmond in 1795.

In this year, also, Mr. Gardner, the chief draughtsman, was furnished with materials for mapping the north shore of the Thames and the North of Kent. The triangulation during 1799 covered an area, generally north and west of London, of some 5,000 square miles, reaching a little to the north of Coventry, and west as far as Broadway Beacon in Gloucestershire.

Mudge remarks that "the highest advantages would accrue—a word he was very fond of—to geography, were the ideas of the Astronomer Royal carried into execution (and which I shall endeavour to do at some future period), respecting the discovery of the difference of longitude between Greenwich and some very remote point on the western side of the island (St. David's Head, for instance), by means of timekeepers, carried backwards and forwards in the mail coaches."

**Position of the Scilly Isles.**—The angles to points in the Scilly Isles were observed from stations near Land's End in 1797; and, when the distances were subsequently computed, they revealed a large error in the hitherto accepted longitudes of those islands. Mudge says, "How in a maritime country like our own, where chronometers are in such constant use, so great an error as 26′ 37″ (1m. 46½s. in time), in the longitude, should have remained undetected except by one person, is surprising. J. Huddart, Esq., visited the Scilly Isles, having with him a watch made by Arnold, and obtained his time at that spot, in the island of St. Mary, where the body of Sir Cloudsley Shovel is said to have been thrown ashore . . . he then found a large difference between the real longitude and that published in the *Requisite Tables*."

We shall see that, forty years afterwards, important islands off the coast of Scotland were, before the publication of the Ordnance maps, misplaced on the charts and maps by almost equally large distances.

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**Terrestrial Refraction.**—Mudge devoted much attention to the subject of terrestrial refraction, and, in the account for the years 1797–99, the refraction, in quite a modern way, is given as a fraction of the contained arc. He mentions the great uncertainty and variability of terrestrial refraction and quotes an instance of this in the vertical observations from Pilsden Hill to Glastonbury Tor. It was not found possible to devote very much time to the subject, but Mudge and Woolcot made careful hourly observations at three stations, noting the temperature, air pressure and state of the wind. The mean value of the coefficient of refraction at these stations worked out to about ·09. Mudge says, "the little done on this subject points out the necessity of doing more."

**The First Ordnance Map.**—By the "first ordnance map" is meant the first map issued, by the Ordnance Survey, for the use of the public. It is stated, in the Account for 1795, that a necessity existed for "completing the Map of Kent for the Board of Ordnance, by order of the Master-General." In the Particulars relating to the operations of the year 1798, Captain William Mudge says that the Survey of Kent was renewed in this year, "as the Master-General had given directions to prepare ample materials for completing the map which meets the public eye with this article." "This article" was read before the Royal Society on 3rd July, 1800. But in the Preface to the Account of the Operations from 1784 to 1796, *i.e.*, Volume I, Mudge and Dalby state that Mr. Faden was permitted "to engrave, under certain restrictions, this Map of Kent for public use. . . . These instructions have been carried into effect, with the assistance of Mr. Gardner, by whom the map has been finished in a masterly manner, and will be published by Mr. Faden in the course of the present year" (1799).

This map of Kent, the first of the ordnance maps, which is thus variously described, was actually published by W. Faden of Charing Cross on 1st January, 1801. It is on the scale of 1 inch to 1 mile and is engraved on copper, in four sheets, each about 33½ inches by 22½ inches. It includes the East part of London, the South part of Essex and the whole of Kent. It is entitled *General Survey of England and Wales, an Entirely New and Accurate Survey of the County of Kent with Part of the County of Essex. Done by the Surveying Draughtsmen of His Majesty's Honourable Board of Ordnance, on the basis of the Trigonometrical Survey.* There is a dedication to Lord Cornwallis and the Board, *by their most obedient and faithful servant, W. Mudge.* The dedication is dated, *Drawing Room, Tower, January 1st,* 1801. The first of the ordnance maps appeared, in fact, on the first day of the new century. Thos. Foot was the engraver, and it is probable that the engraving was done under Faden's direction. Although the hachuring is, in parts, a little harsh, the work appears to be equal to the best continental

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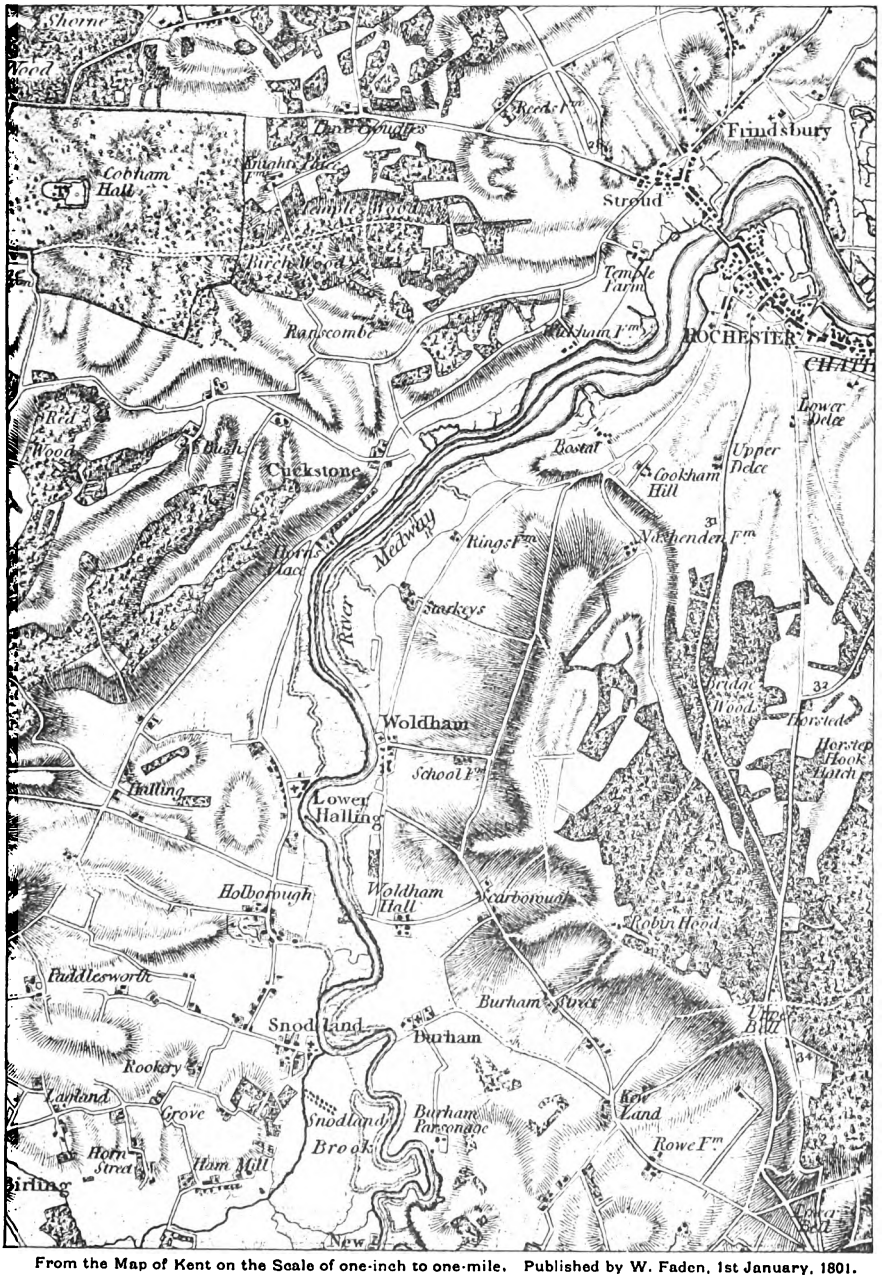
# THE FIRST ORDNANCE MAP.




From the Map of Kent on the Scale of one-inch to one-mile. Published by W. Faden, 1st January, 1801. Dedicated to the Master-General and Honourable Board of Ordnance, by W. Mudge.

*Ordnance Survey 1924*

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productions of the time, and a good deal superior to the early Cassini maps and the general run of English county maps. It is curious that the next county to be published, Essex, has the title, *Part the First of the General Survey of England and Wales, done by the Surveyors of His Majesty's Ordnance under the direction of Lieut.-Colonel Mudge, of the Royal Artillery, F.R.S.* This is in four sheets, each 23 inches by $34\frac{3}{4}$ inches. It has the imprint, "*Published April 18th*, 1805, *by Lieut.-Colonel Mudge, Tower. Engraved at the Tower.*" So that by this time the surveyors and engravers were under Mudge's orders, and the maps were published by him. The hachuring of the Essex sheets shows an advance on anything done before, in fact, it had practically reached its final form.

The old hill-hachuring of Cassini's Carte de France left much to be desired: "Mais où la carte de Cassini se montre le plus inégale, toujours médiocre, souvent inférieure aux cartes locales contemporaines, c'est dans la représentation du relief. Les hachures, supposées suivant les pentes, ne sont d'accord ni avec leur raideur, ni avec l'importance des différences de niveau, ni avec les formes du sol. Elles n'expriment guère le terrain, à la manière d'une esquisse très grossière, que lorsqui'l s'agit de vallées d'érosion ouvertes dans l'épaisseur d'un plateau."*

This is exactly the idea that the present writer received from studying the sheets of the Cassini map; before reading Colonel Berthaut's account, he had written that this French map gives the impression of deep river channels in an eroded plateau. The English county maps, published before 1800, usually give the same impression; take, for instance, the interesting map of Wiltshire, on the 2-inch scale, published by Andrews and Dury in 1773, or the map of Essex, by Chapman and André, published in 1777. The Ordnance Map of Essex of 1805 does really, on the other hand, represent the relief almost as well as it is possible to do by hachures; where this system fails is in representing long slopes and gentle undulations. It is not, on the whole, a satisfactory method and is now almost obsolete.

The scale of the Carte de France of Cassini (de Thury) was 1 : 86400. It was begun in the field in 1750, and was finished in the field in 1789, but its publication was not completed until 1815. Napoleon was unwilling that his enemies should possess a complete and detailed map of France—"l'Empereur estimait qu'une carte détaillée est une arme de guerre." Its successor, the "Carte de France au 80,000e", was proposed by Colonel Bonne in 1808; the project was revived in 1814 by General Bacler d'Albe, Directeur du Dépôt de la Guerre, and was supported by Laplace in 1817, who presided over the committee which was the first of many to discuss the

* *La Carte de France*, 1750–1898. Col. Berthaut, Service Géographique de l'Armée.

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scheme. The work was begun in 1818; in 1854 about two-thirds of the sheets had been published. The series was not finished until 1875.

These facts are mentioned to give an idea of the slow rate of progress of these celebrated French maps. It was just the same in this country. We shall see that the old one-inch dragged on for more than half a century.

**Mudge's Arc of Meridian.**—The geodetic operation with which Mudge's name is most closely associated, an operation which, in fact, he largely carried out himself, is the measurement of an arc of meridian from Dunnose, near the southern extremity of the Isle of Wight, to Clifton, a village in Yorkshire, a distance of 196 miles. The objects of this measurement were, first, to determine the varying curvature of the meridian passing through the greater part of England, for use in computing the latitudes and longitudes of the triangulation; and the second purpose was to provide additional information with regard to the figure of the Earth. With regard to the first object it may be pointed out that there was no strict necessity for determining latitudes and longitudes, so far as concerns the making of a one-inch map of England and Wales, or even of Great Britain. For the whole map could have been plotted—as, indeed, it was later on—by a well-known system which is almost the equivalent of assuming a plane earth; and for such a small range in longitude the errors involved in the projection give rise to no practical inconvenience. On the other hand, latitudes and longitudes derived from the Ordnance Survey were required for nautical charts, especially of the coast-line and islands; and it is known that at the beginning of the nineteenth century there was very considerable uncertainty about the positions of the surrounding small islands, especially, of course, with regard to their longitudes. We may, therefore, consider the measurement of this arc as a very proper operation, and a necessary one, if full use was to be made of the Survey.

Mudge considered carefully the best meridian to choose for the purpose. That which passes through the greatest extent of the land-surface of Great Britain is the meridian three degrees west of Greenwich, but this has the disadvantage of traversing much mountainous country, including the marches of Wales, Cumberland, and the eastern highlands of Scotland, and the observed latitudes along such a line would certainly be much affected by local attraction; so Mudge, in order to avoid a line so likely to involve serious deflections of the vertical, chose the meridian of Dunnose.

The account of the measurement was read by Mudge before the Royal Society, on June 23rd, 1803. It was published in *Philosophical Transactions*, and republished by William Faden in 1804, as the second part of Vol. II of the *Account of the Trigonometrical Survey*.

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Many pages of this account are devoted to a description of Ramsden's zenith sector, the remarkable instrument with which the latitudes were observed. This instrument had been ordered by the Duke of Richmond before 1795, and it is stated that Ramsden "from the beginning of the year 1800 till the middle of the following summer, had proceeded with little interruption, except from illness, towards its completion. The whole was brought so near to a conclusion before he died, that Mr. Berge found no difficulty in rendering it sufficiently perfect." It was delivered to Mudge in April, 1802, and, after some days' testing and experimental observation at Greenwich, it was set up on the down at Dunnose on the 9th May. Mudge says that one very material service accrued to himself during the time that the sector was being tested at Greenwich, and this was "the advice and instruction I received from the Astronomer Royal, for the successful management of the sector, by which I scrupulously governed myself throughout the whole of the subsequent campaign."

The zenith sector, Ramsden's last work, was in every respect a noteworthy instrument and a short description of it may not be out of place. It had a telescope eight feet long with a four-inch object glass. Great pains were taken to prevent any flexure of the transit axis. The position of the zenith was given by a plumb-bob, and zenith distances could be read by micrometers for $7\frac{1}{2}$ degrees each side of the zenith. In the observations every imaginable precaution was taken by Mudge; thus, thermometers were read at various levels in the observatory tent in order to correct for any unequal expansion of arc and telescope. It is safe to say that no such accurate observations had ever before been taken in the field. The observations were admirably accordant; the measurement of the celestial arc of meridian between the zeniths of Dunnose and Clifton, by 17 different zenith stars, gave a maximum discordance of 4·19″ and a probable error of 0·18″, an excellent result—achieved more than a hundred and twenty years ago. Mudge observed with this instrument at Dunnose in May and June, 1802, at Clifton in July and August, and at Arbury Hill, in Northamptonshire, in September and October of the same year.

It is curious that, though the title is an Account of the measurement of an *arc* of meridian, in the text Mudge throughout uses the word *arch*, for that portion of the instrument by which the angles were measured; he writes of celestial *arcs*, but instrumental *arches*. In the account for 1800–09 he writes of terrestrial *arches*.

The angles of the great terrestrial triangles, connecting Clifton with Dunnose and the previously executed work in the south of England, were observed in 1800 and 1801 with the 3-ft. theodolite. A base was measured on Misterton Carr, not far from Clifton, in 1801, with Ramsden's two 100-ft. chains. This was the fourth base to be measured during the survey operations, the others being those

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measured at Hounslow Heath, Romney Marsh, and Sedgemoor (in 1798), the latter being a base of verification for the work in the west of England. The mean length of the Misterton Carr base was found to be 26,347·7 feet of Ramsden's standard. Allowance for standard being made, this base comes out very well when tested by the final O.S. results. For a discussion of the length of a degree of the meridian Mudge was able to use the well-determined latitudes at Greenwich and Blenheim, as well as those observed by himself at Dunnose, Arbury and Clifton.

The length of a degree of the meridian, in the mean latitude 52° 2′ 20″, was found to be 364,920 feet, a quantity which does not differ much from modern values. But Mudge was greatly concerned to find that the length of a degree in the southern portion, from Dunnose and Arbury, was greater than that in the northern portion, from Arbury to Clifton; whereas, if the earth had the shape of an oblate spheroid, the reverse should have been the case. This was a disappointment to him, as he had hoped that the stations chosen were reasonably free from local attraction. But he never doubted that the anomaly was caused by local attraction, and he was right.

Mudge, in common with the geodesists of his age, treated mountains as supported by the solid crust of the earth; a section of the crust through the mountain being imagined to have just so much extra matter piled on top of it. Now, the modern view, based on much experimental evidence, and chiefly due to the labours of Archdeacon Pratt, in India, some seventy years ago, and of Dr. Hayford, formerly of the United States Coast and Geodetic Survey, in recent years, is briefly this: Mountains are not "supported" by the solid crust; the existence of a mountain may be taken as a proof that there is, in the crust below it, material lighter than the average. In the same way, it appears probable that under the oceans the material of the crust is heavier than the average. Hayford has shown that this compensation, or balancing of high land by deficiency of density underneath it, and *vice versa*, probably takes place within a depth of about 100 kilometres, or 70 miles. So that computations of the deflections caused by the visible topography give results, in the case of hills, which are almost always too great, and are apt to be very misleading. When the effect of compensation is taken into account it is necessary to extend the computations to great distances. Moreover, though the compensation is probably very perfect when large continental areas are considered, it is not so for small areas or for small hill features, and the compensation may be considered to be spread through some distance horizontally. Also, local attractions are largely modified by local, and not general, abnormalities of density which may be only a relatively small depth below the surface.

The general condition of balance is known as *isostasy*. Much

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has been written on the subject by Dr. Hayford and Mr. W. Bowie, of the United States Coast and Geodetic Survey, and by Sir Sydney Burrard, formerly of the Survey of India.* But the science of geodesy arrives slowly at its results and finality in the discussion of this matter of isostatic compensation has not yet been reached, though much progress has been made.

We need not, therefore, be surprised that Mudge's measurement of a single arc of meridian, less than three degrees long, did not give minutely reliable results, or serve to determine the figure of the earth. But the combination of many arcs, both along meridians and along parallels, and geodetic observations spread over Europe, the United States, and India, have given us very accurate information with regard to the mean figure, that is to say, the ellipsoid of evolution which will best fit the geoid, or water surface at mean sea-level. We can now say that, though we are still uncertain as to the variations of crustal density and the exact mechanism of compensation, we know the length of each of the earth's semi-axes to within about 100 metres, that is, to within one part in sixty thousand. But in Mudge's day there was no such exact knowledge of the figure of the earth, and the mean curvature which he obtained from his arc was required for, and used in, the construction of the one-inch map.

Although Mudge had not the solution, he had perfectly clear ideas as to the nature of the problem. In the Account printed in 1801 he says, with reference to " the uncertain state in which we remain, with respect to the figure of the earth " : " If the earth were homogeneous, it would necessarily be an ellipsoid ; and, were its diameter known, the longitudes and latitudes of places on its surface might be accurately computed, provided their geodetical situations were correctly ascertained, and the latitude of one station in the series of triangles truly determined.

" As there is, however, great reason to suppose that the earth is not any regular geometrical figure, from the impossibility of reconciling the results of the various measurements . . . some uncertainty must remain with respect to our deductions ; but there seem to be reasons for supposing the errors . . . are confined within moderate limits."

**Simon Woolcot.**—Writing in 1800, Mudge said that " whilst I lament the loss of a man [Dalby] so perfectly calculated to assist me in this arduous undertaking, I derive every consolation from a knowledge, founded on experience, of the talents and abilities of Mr. Simon Woolcot." Woolcot joined the Survey as mathematician and observer, in succession to Dalby, in the latter part of 1799, and his service was continuous until his death in 1819.

* See also *The Earth. Its Origin, History and Physical Constitution.* by Dr. H. Jeffreys, M.A., D.Sc. University Press, Cambridge, 1924.

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A few of Woolcot's letters have been preserved and these throw some light on the experience of the field-workers in the early part of the nineteenth century.

On the 4th May, 1804, he writes to Mudge from South Molton :—

" A considerable time has elapsed since the Draughtsmen of the Tower were favoured with Warrants, from a recommendation of the Master-General, as a measure highly expedient to facilitate the execution of Military Surveys, etc. I must say, I feel a considerable degree of uneasiness, as I have not received the favour of a similar indulgence, since the authority of a warrant is now become so necessary to guard me, particularly on the coast, from those insults and interruptions, in the execution of my business, which I have so frequently and so lately experienced. . . . "

On the 22nd December, 1812, he writes to Colby from Kimbolton :

" The weather . . . set in so unfavourable that notwithstanding my waiting day after day for a change I was at last compelled to return without having completed what I intended when I set out. I have returned with a slight cold and a broken Gig—however, it does not require much fortitude to reconcile oneself to accidents like these. I was sorry to find Mr. Gardner on my return so long waiting. . . . He wishes to have your permission to proceed immediately with the Survey of Norfolk. No coach passing through Kimbolton for London this day, Mr. Gardner is under the necessity of delaying the sending the Diagram of his triangles until to-morrow.

" With respect to Messrs. Hyett and Stevens I think the most convenient edge will be from Towcester on the main road in a straight line through Watling Street the old Roman way. . . . "

In the next letter there is a sentence which shows that some of the work was carried out in the field on the one-inch scale. Woolcot, writing from Kimbolton on 27th November, 1812, says :—

" Since I received your last letter I have recomputed the Cambridgeshire triangles and will lay them down on the inch scale for Mr. Yeakell as soon as possible."

In another letter, of about the same time, but undated, he gives the " latitudes " and " longitudes," *i.e.*, the co-ordinates, of certain points in Scotland, namely, Kellie Law, Red Head, Bell Rock, Dundee Law and East Lomond, with reference to Delamere ; showing that it was then intended to plot the one-inch map of Great Britain from one origin. Later on this excellent idea was given up. He ends the letter :

" I wish you fine weather for your zenith sector observations that you may not be detained long in the inhospitable Isle of Shetland."

In a letter dated May 5th, 1815, he writes :—

" I sent Mr. Dawson by the coach of yesterday a diagram of the points and distances on the two-inch scale in the neighbourhood of

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Dolgelly and Cader Idris. . . . I am happy to learn from you that the United States of America have manifested such a laudable spirit of exertion by procuring instruments from this Country of such transcendent excellence for the prosecution of their Survey. . . ."

On 10th January, 1816 :—

"I am glad you have gotten a Board Order for the payment of the 1/5d. per day, etc."

On July 4th, 1816, from Carnarvonshire :—

". . . Colonel Mudge desired me on my way to Wales to call on Mr. Dawson and to learn from him for what part points would be first wanted. Mr. Dawson informed me that as Caernarvonshire would be principally the business of the present year he could wish to have points for that district as soon as possible. . . . The range of mountains is more extensive in this neighbourhood and of superior bulk and eminence and has also in general a nearer approximation to the coast, which, perhaps, may account for a greater attraction of the humid vapours exhaled from the sea. . . .

"I expect Mr. Dawson will be very soon at Caernarvon as I understand from Mr. Forbes and his nephew Mr. Budgen. . . ."

In this letter he gives his value of the height of Snowdon as 3557 feet.

On July 15th, 1818, to Captain Colby, LL.D., etc., then in Scotland :—

"Good and evil are intimately blended and inseparable in this life, both in action and in sufferance. Your future almost inaccessible positions will supply you with an antidote of some small efficacy, . . . it will perfectly free you from all disagreeable intrusions. All those swarms of idle holiday visitors will visit you no more, they will remain at home, like flies from tempests all couched under shade. . . . I have not heard from Colonel Mudge since I left Town. I have informed him in what manner I intended to proceed with the internal survey. . ."

At Macclesfield on December 22nd, 1818, to Capt. Colby :—

"So long a time hath elapsed since I received a letter from you that I feel very uneasy on the occasion. I wrote to you at the Tower about five weeks since on the supposition you were then returned from your expedition to France with the Zenith Sector. I wish to observe that the approaching winter would not allow me to finish the high Peak of Derby. . . . I wrote to Colonel Mudge previous to his going to France that I was in want of Paper. . . ."

The following letter was written to Capt. Colby by William Woolcot, brother of Simon, shortly after the death of the latter :—

"I have this moment received your letter of the 28th and, conformably to your Order, I have enclosed my dear Brother's last Field-pay; which you will be pleased to hand over to the Board. . . . I mean to pay you a visit at the Tower, and whatever papers I may find in my Brother's Gig-box, relative to the Survey, shall be faithfully delivered

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to you. . . . There are also several Books of computed triangles of various Counties, some maps, a Telescope, and one of Beck's patent Protractors, which shall all be returned to you. Besides, I have a good part of the Correspondence between Colonel Mudge and my most affectionate Brother. . . . I, too, should like an inscription over the remains of my lamented Brother, and the following is submitted to your consideration, alteration and amendment :—

*" Sacred to the memory of S. Woolcot, Esqr., Trigonometrical Surveyor, who was born at Southmolton, Devonshire, but departed this life, at Macclesfield, while on the Survey, in the certain hope of a glorious Immortality, on Monday the 19th day of April 1819, in the 59th year of his age,—As a man he was amiable,—as a scholar, most excellent ; few were his equals in the arduous field of Investigation, and none his superiors ; but death inexorable, who pays no distinction to persons, title, nor honor, has in a moment laid this sun of genius in the dust!—The last sad tribute of affection was paid to his remains by his highly-respected Friend Captain Colby, LL.D.*

*" Go ! imitate his Virtues, and become also the heir of Immortality ! Virtue alone will flourish in Heaven when Time & death shall be no more.*

*" As a memorial of that love, which nothing but death could extinguish, this Tablet was erected by his most affectionate Brother."*

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# *A RAPID AND SIMPLE METHOD OF OBTAINING THE MAXIMUM SHEAR AT ANY POINT IN A GIRDER WITH THE USE OF A TABLE OF END REACTIONS.*

*By* CAPT. H. A. BAKER, M.C., R.E.

IN calculating the stresses in an N girder or any type of framed girder subjected to a string of rolling loads the difficulty always arises of finding the maximum shear in each of the panels. Finding the worst stress in any member of a frame under any system of loads entails a considerable amount of work. The most accurate and, perhaps, the simplest method, is that of drawing out influence lines for each member. This method is too exact and lengthy to be practicable in the field. The method adopted under certain conditions is to reduce the rolling load to an equivalent uniformly distributed dead load (E.U.D.D.L.). This equivalent load is then used for the purpose of calculating members that resist bending moment only, *e.g.*, the booms, for which it is quite accurate; but in the case of shear members a percentage—usually 15—is added to this figure and the shear then calculated by the usual head and tail method. Now, this method is only sufficiently accurate where the system of loading approaches a uniformly distributed load. This condition is satisfied in civilian work where there are several lines of traffic on the bridge at once and/or where the axle load is small in proportion to the weight of the bridge. It is not, however, accurate in the case of military bridges because this condition is not satisfied. With a single line of traffic the load is anything but uniform and the bridges are usually small enough for the axle loads to be a large proportion of the total load on the bridge. The maximum shear at any point actually occurs when a heavy axle is over that point and the bridge is loaded on one side or the other with the heaviest string of axles that can follow.

Now, in a single line bridge with axles such as a 6-in. gun and tractor with 10 tons on rear and 1 ton on front axles, the E.U.D.D.L. method must fall far short of the truth, and the addition of 15% is absurd as having no relation to actual conditions. To illustrate this, an example is given showing the results obtained by the 15% method and the actual fact. Take a 64-ft. span, loaded as in *Fig.* 1.

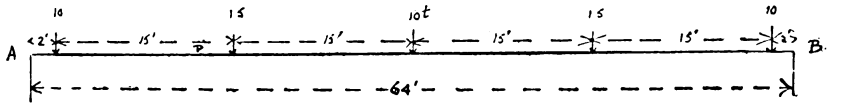


FIG. 1.

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This loading approximates to a 6-in. B.L. gun, but is taken symmetrically for clearness. Impact factor has been neglected in this to avoid confusion.

Then B.M. produced by E.U.D.D.L.

$$=\frac{WL}{8}=\frac{33\times 32}{2}-10\times 30-\frac{15\times 3}{2}=\text{B.M. at centre}$$

$$\therefore \quad \frac{WL}{8}=205\tfrac{1}{2}\text{ ft. tons,}$$

or

$$W=25{\cdot}7\text{ tons.}$$

Then E.U.D.D.L. $=25{\cdot}7$ tons or $0{\cdot}4$ tons per ft. run.

Now let us find the shear 15 ft. from A at a point P.

From above, with the tail at P, moving right, and adding 15% to E.U.D.D.L.,

$$\text{Shear at P due to live load}=\left(49\times{\cdot}4\times\frac{115}{100}\right)\frac{24{\cdot}5}{64}=8{\cdot}64\text{ tons.}$$

Now, actually, the worst shear is when the bridge is loaded as in FIG. 2.

$$\text{Reaction at A}=\frac{49}{64}\times 10+\frac{34}{64}\times 1{\cdot}5+\frac{19}{64}\times 10+\frac{4}{64}\times 1{\cdot}5$$

$$=\frac{68}{64}\times 10+\frac{38}{64}+1{\cdot}5$$

$$=11{\cdot}5\text{ tons.}$$

which is the shear at P due to the live load.

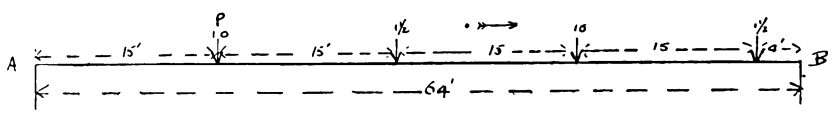


FIG. 2.

∴ the E.U.D.D.L. method is less by nearly *three tons*, or an error of 25% *after* adding the 15% factor. It is clear, then, that this method might lead to failure of a bridge if very eccentric loading were met with.

The method suggested below is shorter than the ordinary head-and-tail method and is equivalent to working out the shear at any point for any system of loads; but advantage is taken of the fact that these calculations have already been made for the Table of Max. End Reactions that will appear in the Manual. This Table of Max. End Reactions shows the max. end reaction for all spans up to 150 ft. for all military loads, by classes, up to tanks. (A Table on these lines is appended.) It has been computed by placing

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the loads in the worst possible position for shear at the end of a girder; that is, with a heavy axle on the abutment and a stream of axles following in the worst possible order.

Now, if we desire to find the shear on a girder AB at any point P,

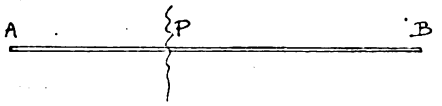


FIG. 3.

the shear will be a max. either when the head of the load has reached P or the tail is at P. If the tail is considered to be at P, the worst possible combination of loads is a heavy axle at P and other axles arranged between P and B. This system of loads will produce a vertical reaction at P equal to the resultant of all the loads divided in the correct proportion between P and B. This is exactly similar to the end reaction at P on a beam length PB, similarly loaded. This can be found in the tables. Let this vertical reaction be $p$ tons —then the reaction at the abutment A is $\frac{PB}{AB}p$ tons, which equals the shear at P.

*For example*—Suppose that an N girder of 10 6-ft. panels is to be designed to carry 3-ton lorries over a span of 60 ft. A timber girder is assumed in this case, an impact factor of 2 being allowed.

Consider the shear in the panel CDKL.

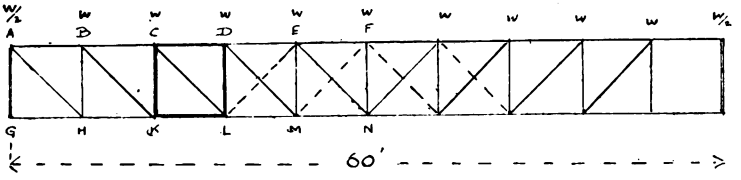


FIG. 4.

The shear is a max. in a positive direction when the tail of the loads is at D, moving right.

From the table we find that max. end reaction on a span of 42 ft. is 13·5 tons (table allows 50% impact factor; factor of 2 is introduced here). Hence

$$R_A = 7/10 \times 13{\cdot}5. \quad \text{Hence shear} = 9{\cdot}45 \text{ tons.}$$

To this would be added the shear due to dead loads only, which is easily calculated as follows:—

Let dead load at panel point = W.

Then $R_A = 5$ W. And shear in panel CDKL $= 5\text{ W} - (2\text{W} + \text{W}/2)$

$$= 5\text{ W} - \frac{5}{2}\text{ W} = 5/2\text{W}.$$

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The shear with the head at C is calculated in an exactly similar manner, though it is considered as though the tail were at C with the load moving left because the rear axle of a vehicle is always the heavier.

In this case reaction at C is 8·5 tons (from Tables).

Reaction at other end of girder is $2/10 \times 8{\cdot}5$.

$\therefore$ shear at $C = 2/10 \times 8{\cdot}5$ tons in a negative direction.

This must then be subtracted from the shear due to dead load only, *i.e.*, $5/2W$ to get the nett pos. or neg. shear.

The only inaccuracy in the method is that due to considering the max. shear in a panel as being when the head or the tail of the load is at a panel point, whereas the actual max. is at a point in between, such that this point divides the panel in the same ratio as it divides the bridge. This error is negligible in practice.

The Table is worked out for 10-ft. intervals. An interpolation can be made with sufficient accuracy for intermediate lengths.

It is hoped that this method may be of some use to those involved in bridge calculations for military loads. It has the merit of being accurate and quick and of using the calculations made at leisure in times of peace.

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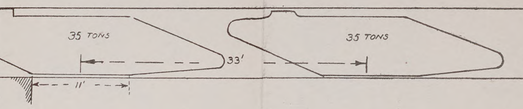
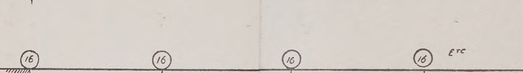
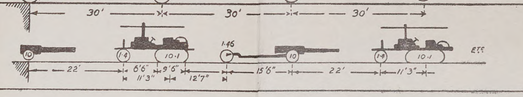
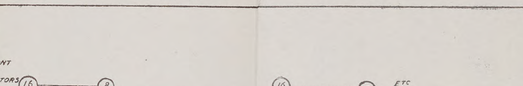
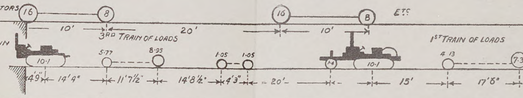
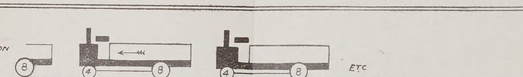
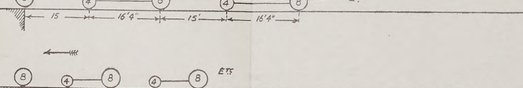
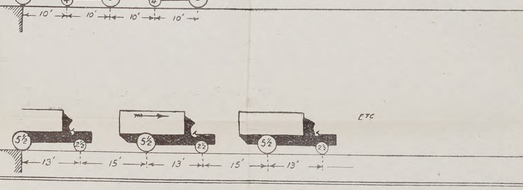
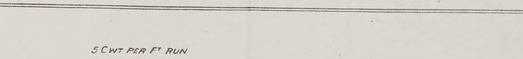
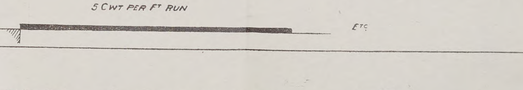
# TABLE OF MAXIMUM END REACTIONS.—DUE TO VARIOUS LOADS (IN TONS).

| | CLASSIFICATION | LOADING TAKEN FOR CALCULATIONS | CLEAR SPAN IN FEET 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | IMPACT FACTOR TAKEN | REMARKS | DIAGRAM OF LOADING SCALES VARY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Tank Loads ... ... | 35 Ton Tanks, 11′ Tracks, Closed up | 17 | 25 | 28·5 | 32·3 | 39·3 | 44·3 | 48·5 | 54·5 | 60 | 64·5 | 70 | 76 | 81 | 86 | 92 | NONE | THIS LOADING NOT ALLOWED ON STOCK SPANS |  |
| 2 | Tank Loads ... ... | Tanks at 75′ Distance, In Clear, Tank as Above | 25·5 | 37·5 | 42·75 | 45·3 | 46·5 | 47·7 | 48·3 | 48·7 | 49·2 | 49·5 | 46 | 50·5 | 53·8 | 56·6 | 59 | 50% UP TO 100′ 33⅓% OVER 100′ | I.F MIGHT BE REDUCED TO 25% THROUGHOUT FOR END REACTIONS | |
| 3 | Heavy Loads ... | 16 Ton Axles, 30′ Apart (Whippet Tank) | 24 | 24 | 24 | 30 | 33·6 | 36 | 41 | 45 | 48 | 52·6 | 52 | 53·3 | 57·3 | 61·3 | 64 | Do Do | REACTION DUE TO MEDIUM 'B' TANK DISTRIBUTION OF LOAD ON TRACK NOT ALLOWED FOR (I.F MIGHT BE REDUCED TO 25% |  |
| 4 | Heavy Loads ... | 6″ B.L. Mk. XIX Gun, Holt Tractors, 22′ between Rear Gun Axle and next Tractor | 15 | 15 | 15·7 | 18·6 | 21·3 | 23·5 | 27 | 30 | 32 | 35 | 33·6 | 36 | 38·7 | 41·35 | 43·6 | 50% UP TO 100′ 33⅓% OVER 100′ | PRACTICALLY THE SAME AS FODENS ON LONG SPANS |  |
| 5 | Heavy Loads ... | 16 Ton Rear Axle, 8 Ton Front Axle, Axles 10′ Apart, Vehicles 20′ Front to Rear Axle | 24 | 30 | 32 | 39 | 45·6 | 50 | 58 | 63 | 68 | 73·6 | 73 | 76·4 | 81·8 | 88 | 92·4 | 50% UP TO 100′ 33⅓% OVER 100′ | A FICTICIOUS CASE THE WORST POSSIBLE COMBINATION OF 16 TON REAR AND 8 TON FRONT AXLE (INCLUDES STRING OF ANY TRACTORS) |  |
| 6 | Heavy Loads ... | 12″ Howitzer Drawn by Holt Tractor, 3rd Train Leading, Followed by 1st Train | 7·87 | 12·06 | 15·8 | 20·36 | 24·3 | 26·9 | 28·8 | 30·36 | 33·25 | 36·03 | 34·2 | 36 | 38·4 | 41 | 43·3 | 50% UP TO 100 33⅓ OVER 100′ | SLIGHTLY WORSE THAN 6″ GUN OVER MEDIUM SPANS |  |
| 7 | Medium Loads ... | 8 Ton Fodens Rear Axle, 4 Ton Fodens Front Axle 16′ 4″ Between Axles, 15′ Axle to Axle of Vehicles | 12 | 13·5 | 15·0 | 18·4 | 24·2 | 25·2 | 26·6 | 29·4 | 32·3 | 35·1 | 33·7 | 36·2 | 38·8 | 41·5 | 44 | 50% UP TO 100′ 33⅓% OVER 100′ | THE WORST MEDIUM LOAD AT PRESENT IN THE SERVICE. 10 TON ROLLER SINGLY GIVES SAME ON SHORT SPANS |  |
| 8 | Medium Loads ... | 8 Ton Rear Axle, 4 Ton Front Axle, 10′ Between Loads | 12 | 15 | 20 | 24 | 28·8 | 33 | 37·7 | 42 | 46·7 | 51 | 49·5 | 53·3 | 57·3 | 61·3 | 65·3 | Do Do | A FICTICIOUS CASE THE WORST POSSIBLE COMBINATION OF 8 TON REAR & 4 TON FRONT AXLE |  |
| 9 | Medium Loads ... | 3 Ton Lorry Motor Bus, F.W.D. Lorry, Workshop Lorry 5½ Ton Rear Axle, 2¾ Ton Front Axle, 13′ Between Axles, 20′ Between Vehicles Axle to Axle, | 8·25 | 9·6 | 10·9 | 13 | 15 | 16·9 | 18·9 | 20·8 | 22·9 | 25·2 | 23·8 | 25·6 | 27·4 | 29 | 31 | Do Do | THE WORST CASE FOR 3 TON LORRY |  |
| | | Berna Lorry, 4·5 Front, (String of at 15′), 5·4 Rear | 8·1 | 10·5 | 12·46 | 15·1 | 17·88 | 20·36 | 22·95 | 25·68 | 28·3 | 30·9 | 29·5 | 33 | 35·4 | 37·5 | 40·4 | Do Do | | |
| 10 | Light Loads ... ... | Infantry in Fours, Crowded (5 cwts. per ft. run), Also G.S. Wagons, Ambulances, Field Guns | 3 | 4 | 4·7 | 5·6 | 7 | 8 | 9 | 10 | 11·3 | 12·4 | 13·8 | 15·0 | 16·3 | 17·5 | 18·8 | NONE INCLS IN 5 CWTS | |  |
| 11 | Light Loads ... ... | Fictitious 2 Ton each Axle, 6 Horse H.D. Team, 8′ 7⅛″ Between Axles, 15′ Between Vehicle and Next Horse | 3·41 | 4·68 | 5·55 | 6·69 | 8·0 | 9·81 | 10·96 | 12·16 | 13·68 | 15·09 | 14·45 | 15·6 | 16·8 | 18·1 | 19·2 | 50% UP TO 100′ 33⅓% OVER 100′ | THIS IS THE WORST 2 TON AXLE LOAD POSSIBLE (NO HORSES ASSUMED) |  |

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## *THE ROYAL ENGINEERS IN BRITISH COLUMBIA.*

THE following address, given by Judge Howay at the Nineteenth Annual General Meeting of the Corporation of British Columbia Land Surveyors, on the 8th January, 1924, and published with the Report of the Proceedings, has been sent to a correspondent by Mr. R. P. Bishop, who served as an officer in one of the Field Survey Battalions during the Great War. It is republished in full, as giving a remarkable tribute to the energy and versatility of the Sapper. The accompanying photographs have also been recently received, by the Commandant S.M.E. (Major-General P. G. Grant, C.B., C.M.G.), whose father, Colonel J. M. Grant, is repeatedly mentioned in the address, from Mr. A. W. Davis, Resident Engineer, Mineral Survey District No. 3 (Kamloops, B.C.), who served in the 171st and 177th Tunnelling Companies, Royal Engineers, during the War.—(ED., *R.E. Journal*).

ADDRESS BY JUDGE HOWAY.

I have to thank you for the opportunity of saying a few words at this your annual meeting, and I have to thank you for the selection of a topic upon which to speak—it is always a relief when someone else does the preliminary work of deciding the subject, and finally, I thank you that you have selected a matter which is connected with the history of British Columbia—the work of the Royal Engineers in this Province, or Colony, as it then was.

In dealing with this question I do not overlook the fact that I am speaking to a body of professional men, and that while they are, as educated men, naturally interested in all those things that go to make up a liberal education, they are particularly interested in those that have special relation to their own chosen profession. And therefore, while I will not pass by in silence the other activities of the Royal Engineers in British Columbia—for that would be to leave a false impression—yet I will naturally stress their achievements as Civil Engineers and Surveyors.

Let me first of all sketch in a little background of history. Of course, I will do this just in a general way, and only sufficient to place clearly before us the condition which this body of soldiers faced when they set out for the then far-away land of British Columbia.

Sixty-five years ago there was a vast inrush of gold-seekers into this land. Let us see if we can picture the region before their arrival. It was in a state of nature—just as it had come from the hand of God—it was merely a vast fur-preserve of the Hudson's Bay Company. Its only civilized inhabitants, some forty or fifty men, in the employment of that Company, scattered in some ten or a dozen forts or trading posts, separated by many miles; their sole occupation, trading with the

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Indians for skins and furs. The only other inhabitants, the Indians, almost as wild as the bear and the wolf and the cougar that, like them, roamed the dense forests that covered this coastal region, or the mink and the marten and the otter that fished along the neighbouring streams.

Then, sixty-five years ago, there went out to the world rumours of the existence of gold in the bars of the Fraser River; and there swept down upon this wild land a great tidal wave of miners and all the flotsam and jetsam that invariably accompanies suddenly-acquired wealth. In three months—May, June and July, 1858—between twenty-five and thirty thousand adventurers left California for this new Eldorado. "Never in the migrations of men had there been seen a rush so sudden and so vast." Thus British Columbia sprang into being—no question of evolution or gradual growth—but merely to-day a wilderness, to-morrow a civilized region. All things had to be provided and at once. Houses, stores, wharves, and all kinds of buildings to be erected; stocks of goods and merchandise of all sorts to be supplied; roads, trails, and bridges to be built; means of transportation on land and water to be provided; government to be established; and law and order to be instituted and maintained.

Sir James Douglas (or rather, plain James Douglas, as he then was), who was the head of the Hudson's Bay Company on the coast and the Governor of Vancouver Island, a separate Colony, was also offered the governorship of the Mainland. Having accepted, he was much exercised on the question of changing the wilderness into a home of civilized man and at the same time keeping in order the lawless element; for many of the new-comers had reputations none too savoury in the land from which they came.

Writing to Sir E. B. Lytton, on 19th August, 1858, he said: "The affairs of Government might be carried on smoothly with even a single company of infantry; but at present I must, under Providence, depend in a great measure on personal influence and management—a position inconsistent with the dignity of the Queen's Government."

A similar thought appears in the mind of Sir E. B. Lytton, the novelist, who was then the Secretary of State for the Colonies. In a letter to Douglas, written in July, 1858, he says "that he intends sending to British Columbia by the earliest opportunity an officer of Royal Engineers (probably a field officer with two or three subalterns) and a company of Sappers and Miners made up of 150 non-commissioned officers and men."

Later Sir E. B. Lytton enters into the reasons for selecting the Royal Engineers for this duty: "The superior discipline and intelligence of this force, which afford ground for expecting that they will be far less likely than ordinary soldiers of the line to yield to the temptation to desertion offered by the goldfields, and their capacity at once to provide for themselves in a country without habitation, appear to me to render them especially suited for this duty; whilst by their services as pioneers in the work of civilization, in opening up the resources of the country, by the construction of roads and bridges, in laying the foundations of a future city or seaport, and in carrying out the numerous engineering works which in the earlier stages of colonization are so essential to the

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progress and welfare of the community, they will probably not only be preserved from the idleness which might corrupt the discipline of ordinary soldiers, but establish themselves in the popular goodwill of the emigrants by the civil benefits it will be in the regular nature of their occupation to confer."

The detachment was sent out in three principal sections; first, Captain Parsons and twenty men; second, Captain Grant and twelve men; third, Captain Luard and the main body. Those accompanying Captain Parsons were principally surveyors; those accompanying Captain Grant were principally carpenters. These two bodies came by way of Panama; as did Colonel Moody, the commanding officer; the main portion of the force, however, came on the *Thames City* around the Horn.

Sir E. B. Lytton took more than a mere official interest in this detachment. He contributed personally to the fund to purchase a choice collection of books for a library—any who remember the old Mechanics' Institute in this city will recall them. It is said that he even made the selection. When Capt. Parsons and his detachment were leaving on the *La Plata*, Lytton came aboard and addressed them. I may take the liberty of a quotation from that rare speech. I do this not only for its connection with my subject, but also that we, as British Columbians, may realize the deep and personal interest in the foundation of this Province which was taken by the author of the *Last Days of Pompeii*. Lytton himself was very proud of being the father of British Columbia; and in 1861 he told the electors of Hertford that he hoped his name would "be remembered in connection with the commencement of a Colony destined to be the wealthiest of all that now speak our language."

It must not be thought that the detachment was merely one of the forty companies into which the Royal Engineers were then divided. It was a picked body, selected out of a large number of volunteers for this service and chosen with a view of having in their ranks every trade and calling that might be useful in such a suddenly formed Colony. It included gardeners, masons, bricklayers, carpenters, tailors, hotel-keepers, tanners, grocers, blacksmiths, photographers, architects, and surveyors; in fact, every walk and avocation in life.

Captain Grant's and Captain Parsons' companies took part in the official launching of the Colony of British Columbia at Fort Langley on 19th November, 1858. Owing to the change from Langley to New Westminster as the headquarters of the force, but little progress was made by these advance parties in the preparation of the Camp for the detachment, with the result that when the main body arrived in April, 1859, only a small portion of the site was cleared and one little log hut erected.

Perhaps as a diversion I might say a word about one of the amusements indulged in by this main body in its long passage from England. This was the publication of a paper, known as "The Emigrant Soldiers' Gazette and Cape Horn Chronicle." It was published "at the editor's office, Starboard Front Cabin, *Thames City*." The editor was that versatile genius, Second Corporal Charles Sinnett. It was all written on large sheets of cardboard. Possibly some here have seen the originals,

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which are at present in the archives in Victoria. The handwriting is so neat and regular that it is difficult to believe that it was written on the heaving deck. Captain Luard read the weekly paper to the assembled company every Saturday night. May I be pardoned for introducing three or four verses from "Huthlicaut's Wedding," an original song that was sung by Sinnett and published in the Gazette.

I'll sing ye, lads, a Falkland sang,
Wi' thumpin' chorus loud and lang,
I'll tell ye o' the gleesom' thrang
At Huthlicaut's braw weddin' O.

The first that cam' was Geordie Cann,
Then Osment too and Wolfenden,
Wi' Jock McMurphy, Dick Bridgman,
Cam' skippin' to the weddin' O.

There was Morey too, and Rogerson,
An' Lindsay cam' to join the fun,
An' Smith cam' ere the feast begun,
At Huthlicaut's braw weddin' O.

There was Normanseel an' blithe Woodcock,
And Launders cam' to join the flock,
An' Sinnett wi' his dirty smock,
Gid faith! he marred that weddin' O.

And so it goes on until the poet (?) comes to the description of the feast. The tables groaned, he says:

Wi' haggises an' fine kale soups,
Wi' brandies, wines, and mint juleps,
Wi' gid brown ale full mony stoups,
At Huthlicaut's braw weddin' O.

Wi' ham an' beef, an' mutton too,
Wi' Athol brose, an' Irish stew,
Wi' pies an' pasties, not a few,
At Huthlicaut's braw weddin' O.

But now let us glance at the work which this detachment accomplished in the four years and a half that it was in this Colony. I must, of necessity, pass over the part they took in the "Ned McGowan War" of 1859, and in the San Juan trouble of the same year. Both these incidents are interesting, but they lie outside our present boundaries.

The early part of 1859 saw them busily engaged in clearing the site of their camp, building the barracks, married men's quarters, store-houses, offices, and other necessary structures; surveying and laying out the City of New Westminster and preparing the necessary plans with all the neatness and accuracy for which their draughtsmen were famous. Some of Corporal Sinnett's and Corporal Launders' plans prepared at this time are preserved in the archives of the Province and show work so exact and so beautifully executed that it is difficult to believe it was done by hand.

During 1859 the Engineers also surveyed the towns of Yale, Hope and Douglas; and established at their camp an observatory, settling its exact position as 49° 12′ 47″ North Latitude and 122° 53′ 19″ West Longitude. The transit used by them, 12-in. Troughton & Sims, in this observatory is still preserved in the archives. In the same year they built a trail from New Westminster to Burrard Inlet along the line on which, two years later, they built the North Road.

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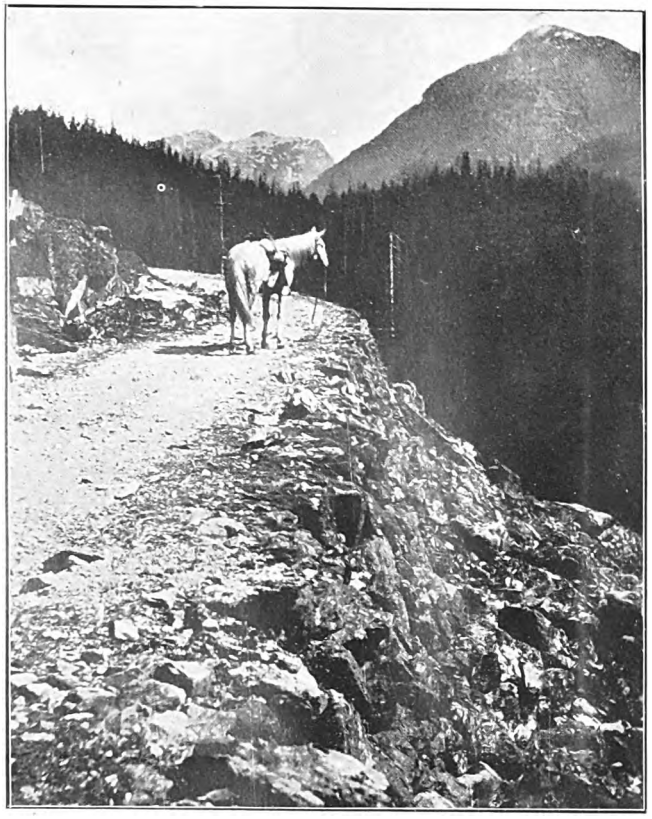
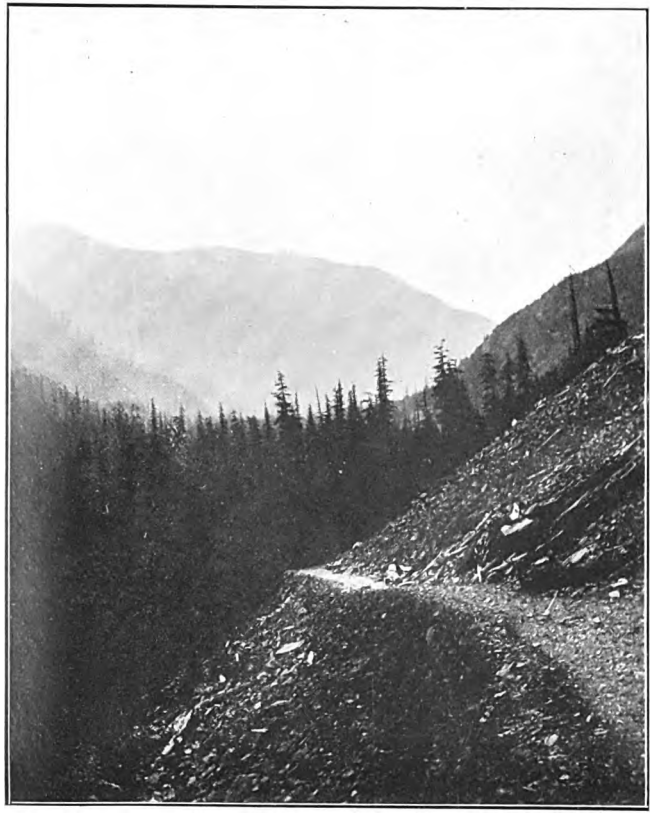


LOOKING SOUTH.



LOOKING NORTH.

Dry wall on Dewdney Trail, seventeen miles south-east of Hope, B.C.; built, about 1860, by detachment of Royal Engineers, and intact in 1924, except where occasional debris has rolled down mountain side.



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But the crying necessity was a wagon road to avoid the Fraser Canyons; a trail had been built (before the Engineers arrived) from Douglas to Lillooet, utilizing the stretches of lakes. In May and June, 1859, Lieut. Palmer surveyed a road, and later in the summer a party of almost a hundred men of the detachment was employed in the actual work.

With the same object in view Lieut. Lampriere and a small party explored from Hope up the Coquahalla, thence along the south branch of Anderson River to Boston Bar and along the left bank of the Fraser to Lytton. On receiving their report another party of the Engineers commenced the work of making a trail along this route, which was completed by August, 1859.

In September and October, 1859, Lieut. Palmer explored the country between Hope and the Columbia River. A perusal of his report, which covers ten closely-printed folio pages, will convince the most sceptical as to the careful and systematic work of the Engineers.

1860.

The demand for agricultural land caused Governor Douglas, in January, 1860, to pass a Pre-emption Act. The survey department was kept busy in laying off the lands applied for. Out of this came a drafting department and a record office. The late A. R. Howse was Clerk of Records.

Everyone knows how the lake expansion of Harrison River completely prevents navigation during many months of the year. In March, 1860, Capt. Grant and eighty Sappers commenced to dig a channel through these shoals; and when the freshet drove them out they resumed work on the twenty-eight-mile section which separates Douglas from the Little Lillooet Lake. This was completed by the end of October. Reporting to the Duke of Newcastle, the Secretary of State, Governor Douglas speaks of it as "a work of magnitude and of the utmost public utility which has been laid out and executed by Captain Grant and a detachment of Royal Engineers under his command with a degree of care and professional ability reflecting the highest credit on that active and indefatigable officer."

In the summer of 1860 Sergeant McColl with another party located the trail from Hope towards Similkameen as far as the summit, carrying it over an elevation of 4,000 ft. with no greater single gradient than one foot in twelve. This was the route later known as the Dewdney Trail, because the construction work was done by the Hon. Edgar Dewdney.

Douglas also set out to improve the trail from Yale up the river. Everyone knows that the old H.B. Co. trail led up Yale Creek and down Spuzzum Creek. Douglas determined to follow the river from Yale to Spuzzum, much the line taken later by the Cariboo Wagon Road. Writing to the Duke of Newcastle, the Governor says: "The arduous part of this undertaking—excavating the mountain near Yale—was executed entirely by a detachment of the Royal Engineers under Sergeant-Major George Cann, and it has been completed in a manner highly creditable to themselves and to the officers who directed the operation."

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In 1860 also the Engineers surveyed the sites of Lytton and Lillooet. Captain Parsons and a party spent the summer in making a reconnaissance survey of the Sumas and Chilliwack country, for the purpose of its future utilization as farming and grazing land, and to carry out a scheme of the Governor for a road to tide-water. At the same time, the Governor was not satisfied with the existing trail from Pemberton to Lillooet, and the Engineers explored the adjacent country without avail in search of a more convenient route.

1861.

The Engineers in 1861 improved the portion of the Douglas–Lillooet Road, lying between Douglas and Little Lillooet Lake. Here a hill, very steep and difficult of access—Gibraltar Hill—engrossed their attention. Sergeant Bridgman and his party, by means of a cut-off, by decreasing the gradients and turning the road at this spot, so improved it that he was dubbed the "conqueror of Gibraltar." Lieut. Mayne, who travelled over this road soon after its completion, speaks of it as "a wagon road that would be no discredit to many parts of England."

Captain Grant and eighty men commenced in this year the road from Hope to the Similkameen. It followed in a general way the Dewdney Trail of the preceding year. By October it had been completed as far as the Skagit Flats, some twenty-five miles from Hope. The remainder of the trail to Similkameen was merely widened, as a temporary expedient, but before it could be made into a real road the glory of Rock Creek and the southern diggings had paled into insignificance before the wondrous stories of the golden wealth of Cariboo.

There was an air of permanence about the Cariboo mines which, coupled with the constant reports of new rich "finds" and increasing output of old ones and with what was equally important, the demand of the miners for better transportation and cheaper materials and food, caused the Governor to consider a road to Cariboo by way of the canyons of the Fraser. Why that road was not built from Hope is a story in itself. The determination to build from Yale necessitated a careful examination of those sheer and stupendous shoulders of rock which confine the Fraser for miles and miles in the Little Canyon and the Black Canyon. And in 1861 the Royal Engineers made a reconnaissance survey of the whole awful region between Yale and Lytton. Those who glide along through that stretch in the palatial sleeping-cars of to-day need a strong imagination to realize its condition when the Sappers crawled like flies around some of those bluffs to obtain the necessary levels. In the archives of this Province is preserved their sketch of this survey, and also the specifications that they drew for the construction of the road. It was apparent that the Fraser must be bridged, and a party of the Engineers under Sergeant McColl, after due examination, selected as the spot, that on which later the Alexandra Suspension Bridge was built.

It was not a case of all work and no play with the Royal Engineers. From November till March the corps was gathered together into its home at the Camp in Sapperton of to-day. This portion of the year

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saw another phase of the versatile Sapper. At the camp a theatre was built and during each winter the members presented from time to time light dramatic pieces, comedies, farces, etc. They were not at a loss even when it came to female parts in their theatrical entertainments, and one or two of the beardless youths obtained quite a reputation for acting in such parts. Dr. Sissall, the bluff and genial and bewhiskered surgeon of the corps, was the admired of all when he used to play Mrs. Bouncer in "Box and Cox." The Engineers also had a social club, the Royal Engineers Club, which during the winter was the scene of many happy gatherings, banquets and dances. Socially the corps was the centre of the social functions of New Westminster in the winter.

1862.

The survey of 1861 having shown that a road up the canyons of the Fraser was feasible though expensive, the Governor concluded to undertake the work, especially as the Douglas–Lillooet Road, with the constant changes from land to water travel and the resultant delays, had never been popular with the travelling public. In May, 1862, Captain Grant, with fifty-three Sappers, began the terrific task, taking as their portion the first six miles out of Yale. By November a magnificent road, cut, or at any rate built, out of the solid rock had been constructed for that distance, connecting there with the road built by contractors. Those who have travelled the remains of this road will endorse John Robson's words: "Some of their work will stand long as the everlasting rocks, an enduring monument of engineering skill and patient toil."

Various other routes—for example, Bute Inlet and Bentinck Arm —strove to compete with the Fraser River Road. To settle the question, Lieut. Palmer explored the latter route. His exhaustive report, like all the reports of these trained men, seems the final word. His minute examination, covering a period of three months, made it clear that the road then under construction through the canyons was far preferable. For fifteen miles the best he could get was an average grade of 182 ft. per mile, a great part of which was over loose rock and precipitous mountain sides. This region was examined ten years later by Marcus Smith in connection with the C.P.R. surveys, but no better route was found.

1863.

The Engineers under Capt. Grant, in this year—1863—located the Cariboo Road from Clinton to Alexandria; but the work of construction was carried on by Gustavus Blinn Wright.

The Governor was not satisfied with the route from the Forks of Quesnel, by Snowshoe Mountain and Antler Creek to Williams Creek —the elevation was too great for winter travelling. Captain Grant then selected the route by way of the Mouth of Quesnel and the Cottonwood. It being approved, the trail was built under his superintendence; the whole sixty-three miles being completed by September, and so passable that the Captain rode the whole distance in one September

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day. Lieut. Palmer, addressing the Royal Geographical Society in March, 1864, declared it to be " the one good trail in Cariboo."

Under Lieut. Palmer the Engineers built, during the summer of 1863, the first stretch of nine miles of the Cariboo Road from Spence's Bridge eastward along the Thompson River, where it connected with that constructed by William Hood.

In the Fall of 1863 Joseph Trutch finished the Alexandra Suspension Bridge, but before the Governor would allow traffic to cross he required it to be passed by the Engineers. Lieut. Palmer, after careful examination, applied a sort of rough practical test. A four-horse team with freight wagons containing a load of three tons was driven over the bridge, but the deflection was inappreciable—less than a quarter of an inch.

In this year also a party of the Royal Engineers under Lce.-Cpl. George Turner surveyed the original Lots 184, 185, 186 and 187, upon which a part of the City of Vancouver now stands, and made a complete traverse of the shoreline from Hastings Townsite around Stanley Park into English Bay and False Creek. Incidentally, it may be added that the reservation of that spot is due to Colonel Moody, and thus the citizens of Vancouver owe to the Royal Engineers the largest and most beautiful natural park contiguous to any city in Canada.

In this year the Engineers surveyed the suburban lots adjoining the City of New Westminster, and it was while this work was proceeding that the Municipal Council passed a resolution that the land now known as Moody Square be reserved and known by that name in memory of Colonel Moody.

Taking stock of the work of the Engineers up to October, 1863, when the detachment was disbanded, we find that all the important explorations in the Colony up to that time were made by them ; the whole peninsula between Burrard Inlet and Fraser River was surveyed by them ; all the surveys of town and country lands were made by them ; all the main roads were laid out by them ; some of these, including portions of the Cariboo Road, the Hope–Similkameen Road, the Douglas–Lillooet Road, and the North Road to Burrard Inlet, were built by them ; practically all the maps of the Colony and of sections of it were made from their surveys, prepared in their drafting office, and lithographed and published by them at their camp ; they formed, in 1862, the first building society in the Colony ; they designed the first churches (Holy Trinity and St. Mary's, New Westminster, and probably those at Yale, Hope and Douglas) and the first schoolhouse in the Colony ; they designed the first municipal coat-of-arms and the first postage stamps in the Colony ; they established the first observatory, and to them we owe the first systematic meteorological observations in the Colony ; they formed the Lands and Works Department, the Government Printing Office, and printed the first British Columbia Gazette ; they aided in the maintenance of law and order ; and their commanding officer was the first Chief Commissioner of Lands and Works, as well as the first Lieutenant-Governor.

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# *THE DENNIS-STEVENS PETROL-ELECTRIC LORRY.*

*By* CAPTAIN AND BREVET MAJOR J. D. INGLIS, M.C., R.E.

ALTHOUGH there is at present no official publication on this subject, a chapter has been written for the new *Searchlight Manual*, which explains fully the principles and operation of the P.E. lorry. There are, however, a number of points which are not dealt with and which, in the present writer's opinion, have considerable bearing on the satisfactory working of the lorry.

The first point is brush setting. There is a very wide area of sparkless commutation on the machines employed on these lorries, about $\frac{3}{4}$ in. on either side of the neutral position. When the brushes on any machine are moved, obviously the resultant of cross and demagnetizing turns of the armature is moved with them.

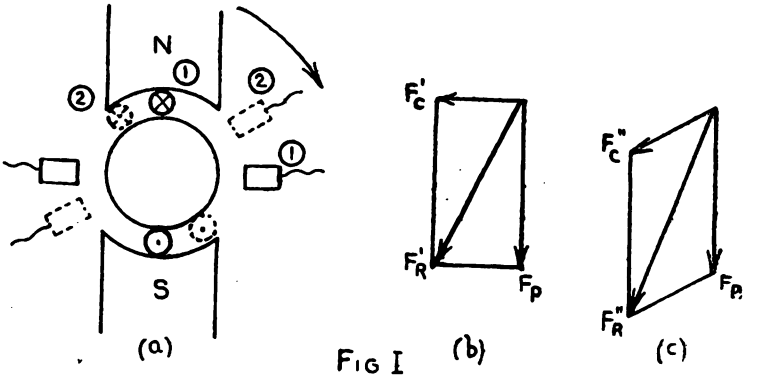


FIG I

*Fig.* I shows that on a generator, by moving the brushes back against the direction of rotation from (1) to (2), the magnetic flux, due to the cross and demagnetizing turns $F_C$, is moved so as to strengthen the resultant main flux $F_R$. Conversely, moving the brushes forward on a generator weakens the main flux. Similarly, by reversing the arrow denoting direction of rotation in *Fig.* I, it will be seen that " brushes forward " on a motor strengthens the field and *vice versa*. The flux due to the interpoles has been omitted for simplicity; a little consideration will show that being equal and opposite to $F'_C$ it actually increases the effect. The fact that the E.M.F. generated is not strictly proportional to the flux $F_R$, but to that component of $F_R$ which is at right angles to the commutating axis has also been omitted. As long as the angle through which

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the brushes are moved is small, this is a reasonable omission, particularly on the generator of the P.E. lorry at starting, which is the important case mentioned later, when the ratio of the field ampere turns to armature ampere turns is low.

The general statement of the effect of brush rocking given above is true of all machines in a greater or lesser degree, but in modern machines, whose field is normally very stiff, the strengthening effect on the flux is small and only operative over a small range of brush positions. In non-interpole machines the strengthening effect only takes place between the neutral axis and the geometrical axis, beyond which the flux is again weakened. The effect, then, of moving the brushes forward is to cause the machine to generate at a lower voltage for a given engine speed. This clearly results in a slightly lower motor speed—in other words, a lower gear ratio. There is, however, a more important effect. At starting before the lorry begins to move, owing to the generator shunt field being shunted across the motor armature, the excitation due to the field is very weak. The effect of the flux due to the cross and demagnetizing turns becomes very marked, so much so that the generator fails to excite at all, whatever its speed, and the lorry refuses to move. The gear ratio has, in fact, become infinitely low. This effect is most noticeable in reverse, where the generator series field is short-circuited, the main field being correspondingly weaker. It is one of the commonest faults in the P.E. lorry and can invariably be remedied by putting the generator brushes back against the direction of rotation. The correct average brush setting, as given by Messrs. Stevens' tester, for the generator is two segments back from the neutral point; the writer, however, finds that this frequently approaches the limits of sparkless commutation. One to one-and-a-half segments gives excellent results from the point of view of starting torque.

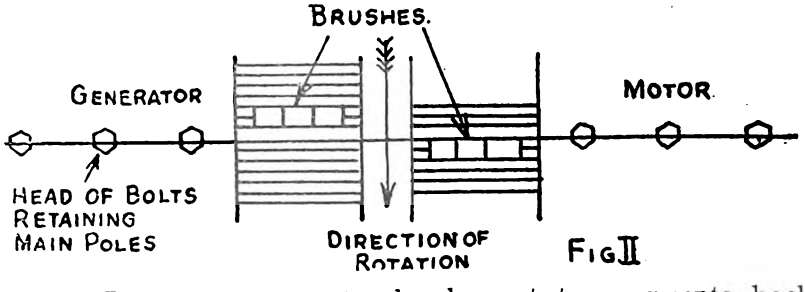

FIG II.

*Fig.* II shows the generator brushes set two segments back. On the motor "brushes forward" will strengthen the field; this will give not only a slower speed or lower gear ratio, but will also improve the torque and is, therefore, desirable in every way. The correct average brush setting is one segment forward from the neutral point and is also shown in *Fig.* II.

Great care must, of course, be taken to ensure that the limits for

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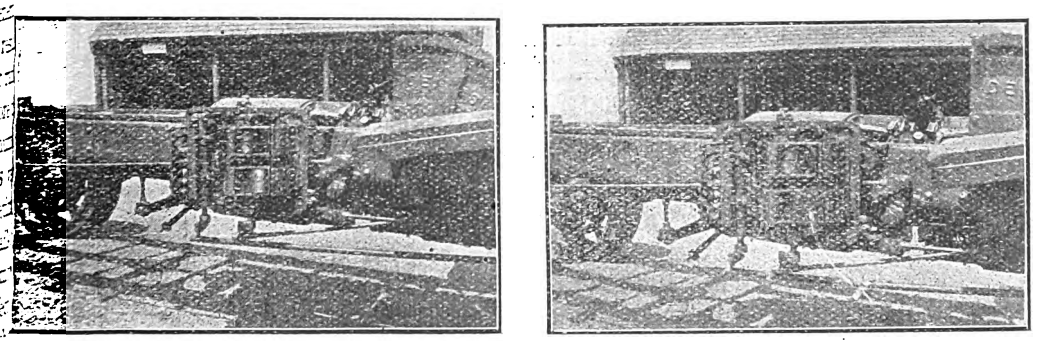
sparkless commutation are not exceeded. The worst condition for sparking is at full load and maximum speed. The motor should, therefore, be tested for sparking at the highest probable speed up a slight incline. The generator should be tested by a stationary run on full load.

It is possible that a lorry may still fail to move in reverse on heavy ground. In such cases the difficulty may be overcome by inserting a resistance in the short circuit path across the generator series windings. This is readily accomplished by placing a piece of sheet iron, preferably rusty, between the lower right hand contacts of the reversing controller as shown in *Fig.* III (*b*).



(*a*) (*b*)

FIG. III.

It is important, if this is done, to put the speed controller in the mid-position; if the speed controller resistance is all in or nearly so, there is danger of burning out the lower elements, which are not capable of carrying the heavy current.

Reversals of polarity of the generator have occurred on these lorries. This may be caused by putting the reversing controller into reverse, while the lorry is travelling forward and *vice versa*. In stationary running a reversal might possibly take place on the sudden application of a very heavy load, if the generator brushes were set too far forward. The writer has no experience of this.

A great deal of difficulty has been experienced in obtaining the requisite power in stationary running. It is at present laid down that 1200 R.P.M. is the maximum permissible engine speed and for most purposes this speed is adequate, but it is interesting to note that the power-speed curve of an engine in average condition does not begin to fall over until the speed reaches 1500–1600 R.P.M. *Fig.* IV shows a power-speed curve taken from an old lorry in only fair condition. This shows that 24 kw. at 110 volts is well within the powers of these lorries.

Good engine speed is essential; it is frequently impossible to get the requisite speed with full field. It should, therefore, be the rule

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to run with the strongest field, which will allow the engine to develop the required power comfortably without labouring.

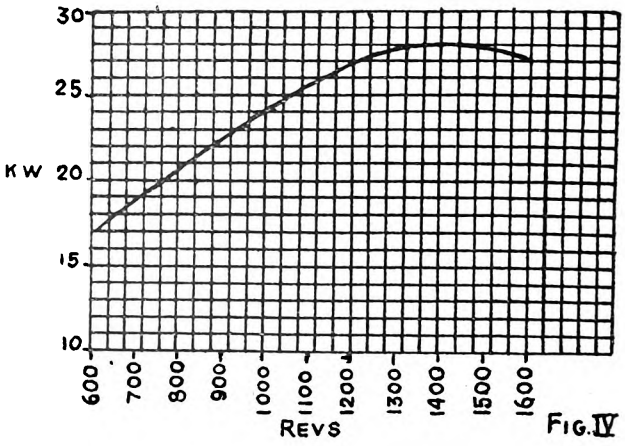


FIG. IV

It is of the greatest importance to have a clear conception of the effect on the voltage of weakening or strengthening the field. Consider first a set running on a fixed throttle position, with a fixed resistance in the external circuit and without governor control; if the field is weakened, the terminal P.D., and consequently the current, will fall momentarily. The engine speed will increase and, provided that it is not at the top of its power-speed curve, it will be capable of developing greater power. The speed, therefore, will rise to such an extent that the terminal P.D., and consequently the current, are greater than they were before.

If, however, the engine had been governed, the speed could not have risen and the terminal P.D. would have fallen.

Other conditions being unaltered, weakening the field will have the following effects:—

(*a*) *Without* governor control, the terminal P.D. will rise.
(*b*) *With* governor control, the terminal P.D. will fall.

This effect is clearly shown by the curves given in *Fig.* V, which are plotted from the readings given in Table I. The heavy lines represent terminal P.D.-excitation and the light lines speed-excitation curves.

The kw.-speed curve given in *Fig.* IV is also taken from those readings.

It should be clearly understood, however, that these curves depend entirely on the condition of the engine; the values cannot be taken to be even approximately correct for all lorries, though the general form, of course, applies to all. Another lorry in average condition gave a maximum of 32 kw. at 1600 R.P.M.

For running with searchlights close governing is most essential.

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Governing is effected by an auxiliary butterfly-valve in the induction pipe; the latter is sufficiently large to allow an output of about 50 B.H.P. from the engine. At lower outputs a smaller induction pipe would be adequate and, therefore, it is necessary to close the governor valve a considerable amount before governing takes place. Thus it is necessary to adjust the governor for a particular speed and also for a particular output.

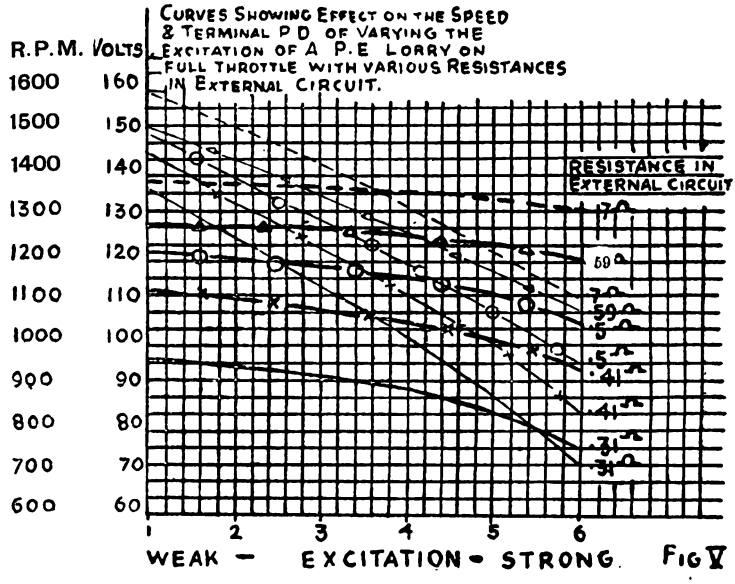

FIG V

The type of governor-adjusting spring fitted to all but the very latest lorries has a very adverse effect on the sensitiveness of the governor. It should in all cases be slacked off, or even discarded. To attain close governing, it is important to minimize back-lash in the governor; this entails careful fitting of the actuating rods and of the governor itself. Unavoidable back lash can be taken up by fitting a light spring, as shown in *Fig.* VI. Increasing or decreasing

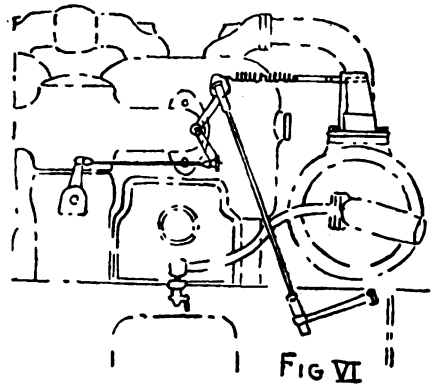
FIG VI

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the tension of this spring by the adjusting screw at the right-hand end will also act as a fine adjustment to the engine speed. Governing is, however, quite satisfactory without this arrangement, provided that the old type of adjustment has been removed.

In order to make clear the method of finding the correct position of the speed controller and field regulator, and of adjusting the governor for any given load and terminal P.D., it has been set out below in the form of instructions.

*Instructions for setting the Speed Controller, Field Regulator, and Governor for running with a* 210 *ampere arc with* 110 *volts at the lorry terminals.*

(1) With governor valve clipped wide open, with full shunt field and speed controller fully retarded, *i.e.*, maximum compounding, place the machine on load, preferably on an adjustable resistance, otherwise on an arc lamp run by a skilful operator.

(2) Instruct the operator or man controlling the resistance to keep the current at 210 amps throughout, by opening or closing the carbons or by adjusting the resistance.

(3) Connect a voltmeter across the lorry terminals and open the throttle wide. As soon as current is steady at 210 amps, read volts.

(4) If the voltmeter reads 112 volts or more, then that is the best position, *i.e.*, full field and maximum compounding. Proceed with governor adjustment, as detailed below in (6).

(5) If the voltmeter reads less than 112 volts, weaken the field either by the shunt regulator or by advancing speed controller or both, until the voltage rises to 112 volts when the current is steady at 210 amps. That is now the best position of the field regulator and speed controller.

*Note.*—Whether it is better in such a case to weaken the field first by the field regulator and only to sacrifice the compounding as a last resort, or *vice versa*, is a very open question.

(6) Maintain the current at 210 amps and full throttle as before. Loosen the governor butterfly-valve on its spindle and, holding it wide open, connect up the governor actuating rods. Now close the butterfly (anti-clockwise) until the voltmeter, which should still be reading 112 volts or more, falls to 110 volts.

(7) Then clamp the butterfly-valve on the spindle. The governor valve is now set for 210 amps with 110 volts at the terminals.

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## TABLE I.

| Total Res. in External Circuit. | Excitation. 6 — Full Shunt Field Max. Compounding. | | | | 5 — Full Shunt Field Min. Compounding. | | | | 4 — Minimum Compounding. Position of Shunt Regulator. ¼ in. | | | | 3 — ½ in. | | | | 2 — ¾ in. | | | | 1 — All in. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V. | A. | Kw. | Revs. | V. | A. | Kw. | Revs. | V. | A. | Kw. | Revs. | V. | A. | Kw. | Revs. | V. | A. | Kw. | Revs. | V. | A. | Kw. | Revs. |
| ·7 | 132 | 192 | 25·3 | 1080 | 135 | 196 | 26·4 | 1200 | 136 | 200 | 27·2 | 1360 | 138 | 200 | 27·6 | 1400 | 136 | 192 | 26·1 | 1550 | 140 | 200 | 28 | 1600 |
| ·59 | 120 | 204 | 24·4 | 1040 | 124 | 216 | 26·7 | 1200 | 125 | 212 | 26·5 | 1240 | 128 | 216 | 27·6 | 1400 | 129 | 216 | 27·8 | 1440 | 126 | 220 | 27·7 | 1520 |
| ·5 | 105 | 216 | 22·6 | 960 | 112 | 228 | 25·5 | 1080 | 116 | 228 | 26·4 | 1200 | 119 | 232 | 27·6 | 1320 | 120 | 232 | 27·8 | 1380 | 122 | 232 | 28·3 | 1500 |
| ·41 | 94 | 224 | 21 | 840 | 100 | 240 | 24 | 1000 | 106 | 248 | 26·2 | 1120 | 108 | 248 | 26·7 | 1240 | 111 | 248 | 27·5 | 1320 | 112 | 252 | 28·2 | 1400 |
| ·31 | 75 | 240 | 17 | 640 | 84 | 260 | 21·8 | 800 | 90 | 272 | 24·4 | 1080 | 93 | 280 | 26·2 | 1200 | 95 | 284 | 26·9 | 1240 | 97 | 290 | 28·1 | 1300 |

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# *INSULATED HOUSES.*

*By* CAPTAIN A. MASON, M.C., R.E.

*Cold Climates.*—In the May (1924) number of the *Journal of the Engineering Institute of Canada*, a paper on the Insulation of Buildings was published by Mr. James Govan, Architect and Inspector of Hospitals to the Ontario Government. He maintains that the transmission and leakage of heat from a warm room can be reduced to a very large extent by the provision of a suitable lining to the walls and ceiling, and that in a country such as Canada, where the winter is very severe, the designing of houses scientifically with this object in view would lead to very appreciable savings in the cost of heating.

His article is of considerable general interest, and few people will disagree with the trend of his arguments, however unconvincing they may find his figures. These are deduced mainly from the results of experiments carried out at the Armour Institute of Technology, University of Toronto.

He quotes the case of an Ontario Government building in which a saving of 50 per cent. in boiler horsepower was effected by the provision of 10 inches of dry shavings above the ceiling. This is by no means an ideal method of insulation, but the result shows that very considerable improvements are easily obtained. Mr. Govan gives as his considered opinion that, in building a new house, "the total cost . . . of effective insulation will be more than met out of the reduced cost of the heating plant and its first year's operation."

The experiments at the Armour Institute were carried out with a patent material called Insulex, and the results, being based on the heat loss through various types of wall, are not entirely practical, but are useful as an indication of the comparative results which can be obtained. The main saving in costs is, of course, in the capital expenditure on a smaller size of heating plant; this leads to a saving in operating and upkeep costs. The saving in the seasons' coal bill is estimated as a result of the experiments as follows :—

| Insulation. | Saving in annual fuel costs over an uninsulated house. |
|---|---|
| 2″ insulex on walls and 3″ on ceilings | ... 45% |
| 3″ insulex on walls and 4″ on ceilings | ... 60% |

It is of greater importance to note that the saving in heat loss is practically the same, whether the type of wall to which the insulation is applied is of wood frame and matchboarding, 8-inch brickwork, or 12-inch brickwork.

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*Hot Climates.*—Now the general principles of insulation are the same whether the problem is to keep the interior of a house warm in a cold climate, or cool in a hot climate, and if one accepts Mr. Govan's thesis in general, as applied to Canada, one is led to consider whether such insulation could not be applied practically to the design of houses in India and the tropics.

There are several differences between the two cases which must be investigated. In the first place insulation costs money, and in the Canadian problem the expense incurred is met by the direct saving in heating costs. In the tropics the only saving possible is what might be effected by designing a cheaper house in which the coolness of the rooms is left dependent entirely on the insulation, the walls and roof being reduced to what is essential for structural purposes only. In military works in India, where economy is essential, the value of the suggestion is thus reduced to the problem of whether the savings which can be effected in bricks and mortar will be sufficient to cover the cost of the necessary insulation. This is a problem which can only be solved on the spot.

The application of insulation to an existing building should add largely to the comfort of its inhabitants and would therefore presumably be welcomed by them, but is not likely to be authorized for Government buildings, except for the purpose of bringing up to habitable standard a building previously unfit for living accommodation.

To come down to details: it will be noticed that in the insulex experiments the insulation was not applied with a uniform thickness throughout. Hot air rises and is, therefore, more likely to escape through the ceiling; where the problem is to keep a room warm, insulation is more important on the ceiling than on the walls. To modify this to tropical conditions, it will be agreed that the more a surface is exposed to the direct rays of the sun, the greater will be the amount of insulation required on that surface.

It would also seem that more scientific methods of ventilation should be introduced; it is curious that they have not come into use before now, as the cost would be very small. The people in a room not only breathe out gases at a temperature of about 97° F., but they also heat up all the air around them; when it is desirable to keep a room warm they are assisting in the process, and for that reason a minimum of ventilation is desirable. But in hot climates the warm gases should be removed at once and replaced by cool air. This can easily be effected by an exhaust fan, working in an outlet at ceiling level, and an inlet at ground level for air which can be kept cool by the dripping of water on to a porous screen.

*Materials.*—In considering suitable materials for insulation, the following table of conductivity coefficients is of interest. The figures have been compiled from various sources in which the data were given in different forms and were to a certain extent contradictory; the

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table must, therefore, be considered only as approximate; the coefficient is expressed in gram calories per square centimetre, the difference in temperature through the material falling at the rate of 1° centigrade per centimetre thickness.

| Material. | Conductivity Coefficient. |
|---|---|
| Stone ... ... ... ... | ·01 |
| Brick ... ... ... ... | ·003 to ·002 |
| Glass ... ... ... ... | ·001 |
| Sand ... ... ... ... | ·0007 |
| Wood ... ... ... ... | ·0005 to ·0002 |
| Cork ... ... ... ... | ·0004 to ·0001 |
| Asbestos wool, Sawdust ... ... | ·0003 |
| Shavings, Charcoal, Felt, Cotton wool ... ... | ·0002 |
| Pure wool, Silicate of cotton, Balsam wool ... ... | ·00015 |
| Air ... ... ... ... | ·00005 |

The first point to notice is that air, which would appear from the table to be an excellent insulator, is by no means so in practice; for its rapidity of movement makes it an excellent conveyor and transmitter of heat.

It is in this respect that the use of insulation may be expected to effect an improvement over the present methods of hollow wall construction. Most of the best materials owe their insulating properties partly to the large quantity of air which they contain in a practically confined state, and movement of the air is only possible by very slow filtration. In most hollow walls, on the other hand, the design permits free circulation within the air space, and leakage in either wall tends to nullify the insulation effect; in the same way the ventilation of the air space, which is frequently provided to prevent trouble from damp, reduces the insulation effect to that of a single wall. Apart from these considerations, economy of masonry can be effected by the application of insulating material to the inner surface of a single wall, where it can be held in place by the plaster.

*Requirements.*—Cost is, needless to say, of primary importance in the selection of a material, and it is its high price that usually rules out cork in its various forms. For India the transport charges will add largely to the price of an imported article, and, therefore, weight and bulk must be considered in comparison with insulating power.

Weight is also of importance in considering the arrangements necessary to hold or carry the insulation and the corresponding modifications necessary in the design of the house. It may be

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possible to obtain a material with considerable structural value in itself, *e.g.*, made up in slabs strong enough to form partition walls without any exterior reinforcement.

A powder has the disadvantage that it is apt to settle, and a vertical insulation may in time develop gaps; this may occur in some materials other than powder and must be guarded against.

Fire resistance should be insisted on; a non-inflammable insulating material would, of course, be of the greatest value in isolating any outbreak of fire, and should, therefore, be considered in designing magazines and stores. Of equal importance is chemical stability; charcoal and sawdust are both liable to spontaneous combustion and should therefore be avoided.

Any tendency to rot, decay or give off smell or gas is undesirable, of course. Insanitary materials like hair felt, which attract and harbour rats and other vermin should not be used.

Both cork and charcoal contain moisture and have hygroscopic tendencies; the ideal insulating material is dry and remains so.

Finally, there are a few practical points to be considered; the brittleness or ductility of the material, the ease of handling or fixing, the thickness available on the market, and that required for efficient insulation.

It will be seen from the above that there are objections of one kind or another to most of the natural materials on the list, and this has led to the manufacture of various types of artificial insulators.

*Supply.*—There are now on the American market a variety of patent substances which combine many of these desirable properties. Among them are Balsam Wool, Cabot's Quilt, Celotex, Insulite and Insulex, experiments with which have been mentioned above.

The best-known English material is Silicate of Cotton or Slagwool. This is manufactured by several firms as lagging for boilers and steam pipes, and by one firm (F. McNeill & Co., Kirkintilloch, near Glasgow) as "Slagbestos," in forms suitable for domestic insulation. It is similar to cotton wool, with the texture of asbestos fibre, and is made by forcing a blast of air or steam through molten slag. The fibres are said to contain eleven times their bulk of air, and the wool is therefore very light, weighing only 14 lbs. per cubic foot. It is not expensive, costing £4 5s. 6d. per ton at the works, or 6½d. per cubic foot in large quantities; to this, of course, must be added the cost of transport. It is also made up in slabs 1, 1½, or 2 inches thick; the cost of a 1-inch slab varies from 4½d. per square foot with a paper backing, to 6d. per square foot with a backing of expanded metal lathing or fireproof plaster. The fact that if compressed it loses its insulating properties, and the difficulty of giving it resistance against cross-breaking without compressing it, limit its structural value, and the manufacturers state that at present they are unable to make it up into tiles or roofing slabs.

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Among the American materials, Balsam Wool and Insulite are both wood fibre products, therefore requiring special treatment to render them fireproof. Insulex, however, is a form of gypsum (plaster of Paris) puffed out, in a similar way presumably to "Slagbestos." It has considerable structural value, a 3-inch Insulex slab under test standing a load of over 23 cwt. over an unsupported span of 2 feet before failing.

*Deductions.*—It appears, therefore, that some of the materials on the market have reached a state of development sufficiently practical to merit a thorough trial under tropical conditions. Small scale experiments in India to compare the cost and insulating power of various materials are suggested first, followed, if satisfactory, by the construction of a few experimental small houses under conditions which will enable comparison with the existing type of house to be made.

Among the possible modifications of design which insulation may render practicable are :—

(1) A more general use of two or more storey buildings in the plains.
(2) The replacement of a sometimes inadequate verandah all round a bungalow by a more generous one placed only where it is likely to be used.
(3) The construction of bathrooms and outhouses with brick pillars and light insulated panels.
(4) Double roofs of heavy tiles or jack arches will no longer be necessary if plenty of insulation is given above the ceilings.
(5) Scientific ventilation as indicated above instead of the present practice of using an electric fan to stir up a stale atmosphere.
(6) Single walls instead of double.
(7) Insulating slabs faced with plaster used to form ceilings and light partition walls where no weight is carried.

Conservatives may say that a double wall with an air space is all that is reasonable for a house. This system has long been discarded in the design of refrigerators, and there is no reason why house design should stand still. "An Englishman's home is his castle." May we look forward to the time when, in the hot weather, the Sahib's home will be his refrigerator? The American newspapers are already giving space to the subject ; full-page advertisements are common, and the *Garden Magazine* shows a house clothed in Cabot's Quilt with the heading "Underwear for Houses." Shall we see in the *Times of India* or the *Pioneer* of the future :—

"Increase your Comfort
Decrease your Drink Bill
Use Frigilite."

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# *THE RUINS OF ANGKOR.*

(*With notes on the construction of the Khmer Temples.*)

*By* COLONEL C. W. DAVY, C.M.G.

THESE imposing relics of the rich and powerful Khmer Empire, which attained its zenith between the ninth and twelfth centuries of our era, are situated in the province of Cambodia in Indo-China. The French Administration, recognizing the supreme importance of good communications for the development of the rich internal resources of the country, has already constructed an excellent system of roads, based on the classification in force in France, and is energetically extending the railway system. That the roads in many localities are liable to be out of action for several months in the year, owing to floods, is unfortunate, but is to some extent compensated for by the fact that during these periods the numerous waterways are in the best condition for navigation.

Travellers proceeding to Angkor usually land at Saigon, and have the choice, subject to seasonal conditions, of completing the last three hundred miles of their journey either by steamer up the Mekong river, or by road *via* Pnom-Penh. The last section of the latter was still somewhat in the rough when I visited the ruins in February, 1924. The journey by river takes about three days; by car, and with a little luck, it may be done in about twenty-four hours. It is worth while travelling one way, in any case, by steamer, as the scenery and the glimpses of native life along the banks of the river are very attractive.

There is an excellent little hotel at Angkor, run by the Messageries Fluviales Company of Saigon, who make a speciality of inclusive fares for tourists which include transportation, hotel expenses, guides, etc. I was there in the so-called cool season, and the temperature during the middle of the day ranged about 90°–95°, but the evenings, nights and early mornings are quite pleasant. As might be expected in a country containing so many sheets of stagnant water, mosquitoes abound, and all the time I was there I bitterly regretted that I had no breeches and gaiters or field boots with me, as thin socks and trousers present no obstacle to these enterprising insects.

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## HISTORICAL.

The researches of French explorers and archæologists, and especially of the members of the "Ecole Française d'Extrême Orient," have already borne fruit in an extensive bibliography on the subject of the origin and development of the Khmer civilization, and lately an interesting and original book has been published in English entitled *Angkor Ruins in Cambodia*, by P. Jeannerat de Beerski.* It certainly strikes one that this work might have been considerably reduced in bulk and have gained in interest by the omission of a somewhat insistent personal note and the product of an almost too fertile imagination, but, nevertheless, M. de Beerski has given us an eminently readable volume, in which he resists with considerable success the almost inevitable tendency in a book of this kind to degenerate either into a superior sort of guide-book or a glorified specification.

I was fortunate in making the acquaintance at Angkor of M. V. Goloubeff, who is engaged in archæological researches on behalf of the Ecole Française d'Extrême Orient, and to his little brochure, *Introduction à la connaissance d'Angkor* I am largely indebted for the following historical outline.

The origin of the Khmers or Cambodians† is still obscure, but there seems to be no doubt that, if not of Hindu blood, they had at any rate become Hinduized by infiltration from India, and their earlier temples and inscriptions show that the influence of the Brahmin caste was supreme. M. de Beerski holds the view that, originally followers of Sivaic Brahminism, the Khmers, after some centuries of war and conquest, rising to the zenith of their wealth and power, were inclined to forsake their cruel and ferocious god for a milder and more humane deity; thus Vishnuism succeeded Sivaism and ultimately Buddhism gained an increasing number of adherents and was held in equal esteem with Brahminism, although the latter never seems to have been displaced from its position of what one may call the established church. In that wonderful shrine, the Baion, the inspiration of Sivaism is clearly seen; it is, as M. de Beerski observes, "the soul of a nation petrified."

The great rectangular enclosure now known as Angkor Thom, covering an area of about four square miles and almost entirely given over to dense jungle, marks the site of the ancient capital which, according to the scanty records available, was founded by King Yacovarman *circa* 900 A.D. We have no space to dwell on the vicissitudes of the Khmer Empire during the next three centuries. Monarch succeeded monarch; war succeeded war; temple was added to temple; until in the twelfth century the architectural

* Grant Richards, Ltd., 18/-.

† "Sons of Kambu," the traditional founder of the Empire.

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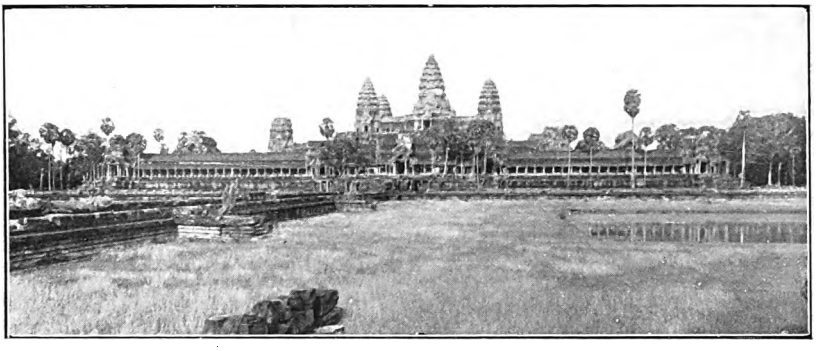
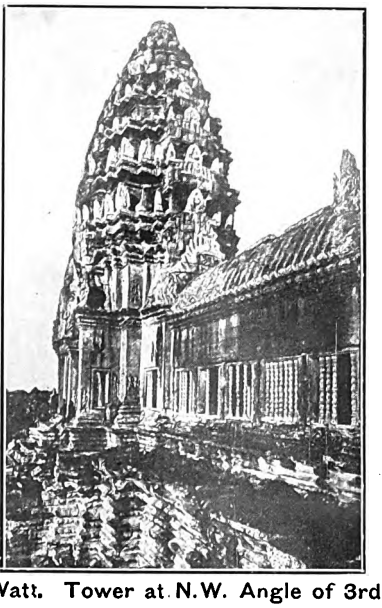
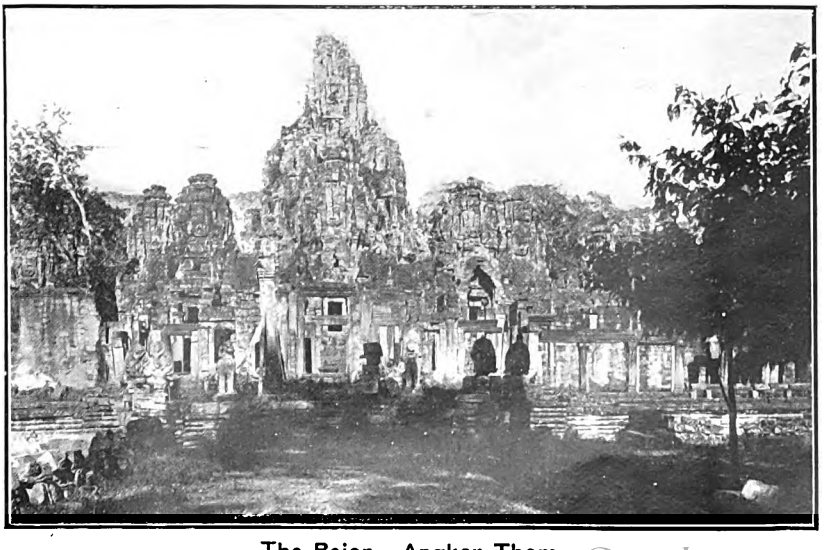
# THE RUINS OF ANGKOR.



Angkor-Watt. West Façade.



Angkor-Watt. Tower at N.W. Angle of 3rd Story.



The Baion. Angkor-Thom.

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zenith was reached with the vast pile of Angkor Watt or " pagoda of Angkor," a " sanctuary where the chief dogmas of a faith are pictorially displayed with consummate feeling, strength and perfection."

After this the story is one of degeneracy and decay. Weakened by perpetual warfare with their hereditary enemies, the Chams, enervated by wealth and luxury, the Khmer Empire was unable to resist the incursions of the warlike Siamese, and from the end of the fourteenth century their innumerable shrines and temples were abandoned to the forest and destruction.

M. Goloubeff tells us the story of the re-discovery of Angkor. It seems that a Dominican monk, in a book printed at Valladolid in 1604, mentions a strange town which the native hunters had lit upon in the depths of the Cambodian jungle about the year 1570.

" This town," he says, " which the inhabitants had neither seen nor known of its existence, is situated in the plain of the Mekong, a hundred and seventy leagues from the sea. . . . It is of wonderful construction and has a very strong masonry wall, four leagues in circuit, on which are represented elephants, leopards, tigers, lions, eagles and dogs. There are numerous inscriptions and letters which nobody can understand. The houses are of stone, very fine, and distributed in regular streets."

We get another glimpse a hundred years later, this time from a French missionary who tells us that the temple of " Onco " (no doubt Angkor Watt) was as famous in those parts as St. Peter's in Rome. It does not appear that any European author again mentions this mysterious city, and it was not until the nineteenth century that the veil was again lifted by a French naturalist, Henri Mouhot, who, in the course of his travels in this region, caught sight, on the 22nd of January, 1861, of the towers of Angkor Watt rising above the tangled sea of foliage.

It would take too long to follow in detail the story, so simply and graphically told by M. Goloubeff, of the interest roused in France by this discovery, of the heroic sequence of sailors, soldiers, administrators, explorers and men of science who devoted themselves, often under conditions dangerous to both life and health, to the deciphering of these fascinating pages of a buried civilization, and to the arduous task of holding in check the ravages of nature. Under the Franco-Siamese treaty of 1907 certain provinces, including the region of the Great Lake, were restored to Cambodia, and thenceforth the custody of the Angkor group of ruins formally devolved on the French government.

## The Ruins.

What is known locally as the Angkor group of ruins, with its principal features Angkor Watt and Angkor Thom, includes a

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number of other smaller temples and shrines, scattered about in the forest within a radius of four or five miles from Angkor Watt. In their general lay-out they are practically identical. A series of rectangular enclosures or galleries on rising levels leads up to and embraces the central feature, the tower, which is the sanctuary, the holy of holies. Other less important towers were constructed at the angles and the axes of the rectangles, and in the larger temples there is often an enclosing wall and a moat.

*Figs.* 1 and 2, which are borrowed from the guide-book compiled by M. Henri Gourdon, show the general plan and detail of Angkor Watt, the largest and best preserved of the temples, and which has been described as the supreme achievement of Khmer art.

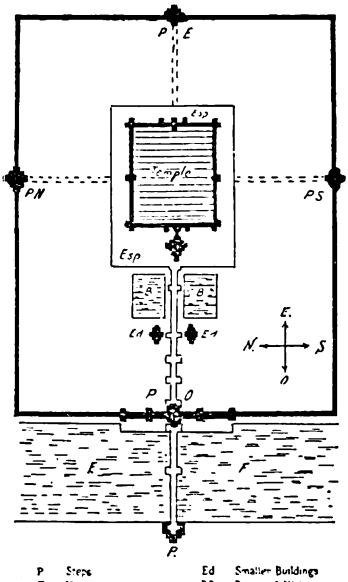


FIG. 1.

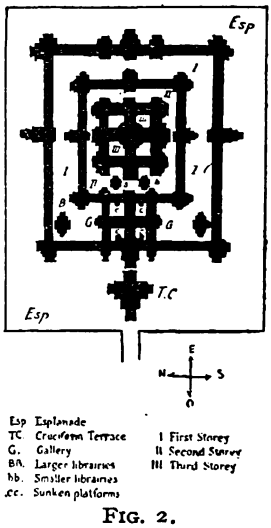


FIG. 2.

Even a cursory inspection of these ruins enables one to realize that, however proficient in the carving of the wonderful series of bas-reliefs and the wealth of floral and emblematic decorations which cover halls and galleries and pillars, the Khmer constructors were woefully ignorant of elementary engineering principles and of the mechanical properties of the materials with which they worked. They had been accustomed to work with timber, and several centuries of experiment do not seem to have taught them that the same methods were not altogether suitable for ponderous structures of stone. To this, rather than the ravages of time, is undoubtedly due the present ruinous state of the buildings which are not older than many of the cathedrals of Europe and far more recent than the monuments of Greece and Rome. That they

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had a suspicion that there was something wrong somewhere is amusingly demonstrated by the not uncommon practice of hollowing out a stone transom over a doorway or window and filling it in with a baulk of hardwood.

A laterite conglomerate and sandstone were practically the only materials used by the Khmers, the former for foundations and mass work, and the latter for exposed faces. The use of bricks was exceptional. Both laterite and sandstone came from the quarries of Kowlen, about twenty miles from Angkor. Much speculation and controversy has been indulged in by the French archæologists as to the precise means by which the ponderous monoliths were transported to the site and placed in position. When it is realized that this was and is still a country in which waterways largely take the place of roads, and that the Khmers were no doubt familiar with such simple appliances as the lever and inclined plane, the problem, given a practically unlimited supply of labour, seems fairly simple.

The sandstone is of a soft and friable character, highly absorbent and easily worked, and for the same reason little able to resist the disintegrating effect of a moist tropical climate. Mortar seems to have been unknown to the Khmers, and in their walls and foundations little or no attention was paid to true horizontal and vertical joints and regular courses (*Fig.* 3). Surfaces in actual contact, however, were smoothed and polished with the greatest care, in order to obtain an exceedingly close joint. The weight-bearing capacity of the soil was evidently not a matter which troubled these casual engineers, and we shall see later that failure to distribute the weight properly in foundations was responsible for disastrous settlements in the galleries of Angkor Watt. *Fig.* 4 shows the typical foundation.

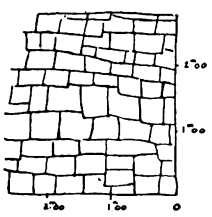

FIG. 3.

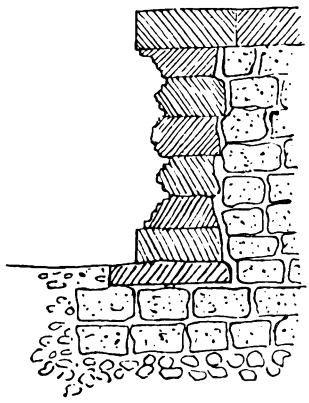

FIG. 4.

The Khmer walls furnish yet another instance of faulty workmanship in the failure to break joint on the straight and the absence of bond

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at angles. Openings for doors and windows were treated as if timber frames were intended to be inserted, and the stone transoms and jambs were actually jointed in carpenter's fashion (*Fig.* 5). The window openings were protected by stone pilasters closely imitating the turned wooden bars so common in oriental buildings.

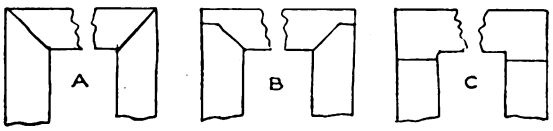


FIG. 5.

*Fig.* 6 is of special interest. It illustrates the typical gallery with (C) the inner wall profusely ornamented with bas-reliefs, a central row of pillars (B) supporting the main vault, and an outer row of pillars (A) supporting the demi-vault. It will be noticed that the horizontal member between the inner and outer pillars is shown as fractured. In Angkor Watt I counted nearly two hundred of these fractures, all precisely similar in position and inclination. In some places the outer pillar had collapsed altogether, carrying the demi-vault with it, but this was exceptional, and also significant, showing that this horizontal member is not essential to stability. It is, indeed, from the constructional point of view superfluous, and some archæologists regard it as introduced purely for ornamentation, but it is more likely to be only another reminiscence of their older work in timber. For a proper understanding of the mechanics of the problem it must be borne in mind that the Khmers were ignorant of the arch. Their " vaults " were formed merely by the prolongation of the walls with a slight corbelling of successive courses (*Fig.* 7). The gap was covered over by a sort of cap. However

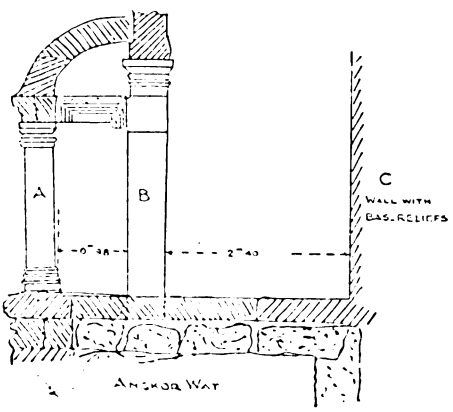


FIG. 6.

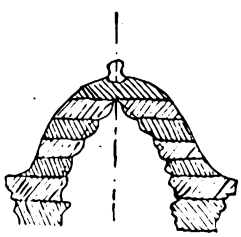

FIG. 7.

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indifferent they may have been, however, to regularity in the masonry of walls and platforms, they seem to have realized the vital importance of truly horizontal courses in their vaults in order to avoid a horizontal thrust on the supports.

What, then, was the cause of this almost universal fracture of the " tie-beam " between the inner and outer rows of pillars? It will be seen from *Fig.* 6 that while the outer row of pillars is securely based, the inner row, which carries not only its proportion of the weight of the main vault but that of the outer vault as well, is based on the slab pavement resting on a somewhat vague foundation. The evidence seems convincing that the fracture of the cross beam is due to subsidence of the inner row of pillars, and that the slight displacement of the stones of the demi-vault thus caused led to a horizontal thrust on the outer pillars, which, as indicated in the figure, are a little out of plumb.

*Fig.* 8 shows a case of an incipient collapse of a vault, instances of which abound among the ruins. *Fig.* 9 shows a typical Khmer tower, constructed after the same fashion as the vaults, but which,

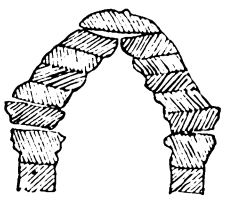

FIG. 8.

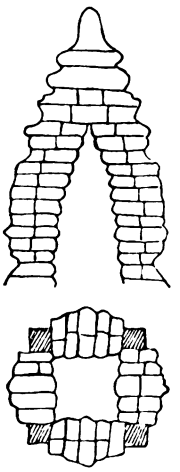

FIG. 9.

owing to the comparatively gentle inward slope, has a relatively larger margin of stability and has survived better than any other constructional feature of the temples.

Ignorance of the true principle of the arch led indeed to disastrous results in the Khmer temples. In other respects also their engineering was defective and the contrast is striking between their incompetence as constructors and the skill evidenced in the setting out of these vast enclosures and such a highly complicated ground plan as the great temple of Angkor Watt, with its series of galleries, courts and towers, on different levels. It would be extremely interesting to know what sort of instruments they used and to what extent detailed

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plans were prepared beforehand. Possibly some reader of the *R.E. Journal* may be able to shed light on this point.

To most people, no doubt, the purely engineering features of ancient monuments do not appeal so much as their architectural and artistic beauty, but many writers have already dwelt exhaustively on the latter side of the Khmer temples and the scope of this article would be largely exceeded if I were to attempt to describe their simplicity and harmony of design, their profuse and ingenious ornamentation, the wonderful panels of historical and legendary bas-reliefs, the inexhaustible wealth of artistic fancy in the carving of volutes and curves, of flowers, dancers, gods, demons, horses, elephants, lions and bulls on almost every inch of exposed surface. Words are inadequate to do justice to these products of infinite patience, generations of toil, and, within the limits of technique imposed by the conditions, a high degree of artistic skill. To appreciate them they must be seen and no traveller in the Far East should miss seeing them if he can help it.

In conclusion let me gratefully acknowledge the kindness of M. Henri Marchal, the Curator of the Angkor ruins, who has permitted me to use a number of illustrations from an article entitled " La Construction des Temples Khmers," contributed by him to a French periodical.

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# *THE WORK OF THE ROYAL ENGINEERS IN THE EUROPEAN WAR*, 1914–19.

## EXPERIMENTAL SECTION.

(*Continued.*)

### CHAPTER 3.—FLARES.

IN December, 1914, the first expedients for illuminating the ground in front of the trenches were tried. They consisted of firework rockets with magnesium stars, shells fired from paper mortars, and hand flares.

The Very pistol, in use at the time to fire the illuminating flare, was not considered good enough, and it was reported that the German pattern and ingredients of the flare composition were better. The Germans also used a hand torch for the purpose.

None of the above expedients were considered better than the Very pistol, and all were unfavourably reported on.

The German flare fired from the "Lichtpistolen," although very similar to our own, was used in such great quantities that its effect was naturally inclined to be exaggerated.

A hand flare, the first ground flare, was tried in February, 1915, but was not favourably reported on, and demands were made on the War Office for a flare which should last at least 30 secs. and light a front of at least 200 yards.

The Germans introduced a parachute light in January, 1915, which seemed to be a great success.

French rockets, after trial by a field company, R.E., were favourably reported on, and Mr. Brock was asked to examine them, and to undertake manufacture of similar rockets.

During November, 1915, trials were held at G.H.Q. with various types from England, and O.C. Experimental Section reported that the Asteroid White floating star rocket was the only pattern which gave sufficient illumination, but was still not as good as the French pattern.

Star shells fired from iron and paper mortars were also tried, but were not found suitable, although the adoption of the paper mortar was urged on account of difficulties in manufacturing sufficient quantities of Very pistols.

About Christmas, 1915, a parachute flare, fired from the 1½-in. Very pistol, was introduced. This gave a bright illumination for

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over a minute and rose to a height of about 300 ft. These flares, however, were not issued in great quantities; a ground flare burning on the ground was always preferred to a flare on a parachute, as the latter lit up the firers' trenches as well as the enemy's. This flare was eventually classed in the category of "Signals" and was used for that purpose.

Christmas, 1915, saw the trial of a parachute flare thrown by the catapult, but in March, 1916, this was unfavourably reported on as not being as good as the 1½-in. parachute flare.

Pistol lights were then experimented on at the Central Laboratory in conjunction with the Experimental Section, and improvements were made to the samples submitted by manufacturers, which, although unsuitable for illuminating enemy trenches, eventually resulted in a ground flare which was introduced for purposes of signalling to aeroplanes. This was supplied in four colours, and burned for about two minutes. The first pattern was made up in cardboard cases as illustrated in *Plate* X, *Fig.* 2; but eventually they were made half size, and packed two together in a tin case so as to be waterproof. Owing to the use of nitrates in their composition they deteriorated rapidly if kept in stock. It appeared that, as the nitrate was hygroscopic, internal action was set up directly the flare was exposed to the air, and as it was impossible to fill the flare with absolutely dry nitrate in the factories, slight action was continuously going on inside, even when the flare was not exposed to the air. Experiments in England were continued by the Ministry of Munitions right up to Christmas, 1918, to improve manufacture, but these flares, although used in large quantities, always had this defect.

As a result of ceaseless experiment the flare composition of the 1-in. and 1½-in. Very pistol lights was improved in time, when, owing to a shortage of magnesium allotted for this purpose, powdered aluminium had to be introduced and further experiment was necessary. The work, however, was taken over by the Chemical Warfare Department of the Ministry of Munitions, and the Experimental Section only carried out trials on these stores, and put up recommendations from time to time in connection with their design for use in the field and methods of lighting.

Through the whole of 1916 and 1917, the great difficulty in the supply of these stores was manufacture in sufficient quantities, and manufacturers at home were hard put to it to meet demands of the Navy apart from the Army requirements.

The main object of all flares being to illuminate the ground where enemy working parties were at work in "No Man's Land," they had to comply with two conditions:—

(i) To have sufficient range to fall on the further side of a party in order to silhouette the figures at work, and

(ii) to give as little warning of their arrival as possible.

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The Very pistol lights were not satisfactory for this reason, because, although supplied with so-called "dark ignition," the star lit as it left the pistol, and always left a slight trail of sparks which would give warning to an observant sentry.

In the summer of 1916 a flare, known as the "Griffin Percussion Flare," was produced by the Experimental Section, and appeared to meet all requirements. This flare, illustrated on *Plate* X, *Fig.* 1, had a range of nearly 400 yards, fired from the 1½-in. Very pistol; and, having a percussion mechanism, it left no trail in the air. On impact it rapidly lit up the surroundings with a bright magnesium flare lasting about 45 secs. The pattern went to England and large quantities were demanded. However, 500 sent out from England in January, 1917, were tested, and several defects which appeared in manufacture had to be remedied before supply could proceed. So much delay occurred in England with its production that attention was turned to designing a flare to be fired from the recently introduced rifle grenade discharger, and manufacture of the pistol pattern in England was given up. Samples received later in the summer of 1917 were not sufficiently well made to be safe for firing.

Experimental work in France was then devoted to the development of a flare to be fired from the discharger, and several patterns were made. A flare of the same diameter as the discharger would have been too large to reach the required range; but a suitable pattern was made to fire from the 1⅝-in. discharger, which was then being experimented with to fire the No. 34 Egg grenade. This discharger was never actually introduced owing to the development of the percussion grenade; and attention was turned to a projectile in the form of an arrow to be fired from the 2½-in. Mills discharger. Difficulties, however, were met with in France in filling the magnesium into sufficiently small diameter tubing to ensure satisfactory burning, and strong steel tubing was difficult to obtain. A suitable weapon, however, was produced by the Mechanical Inventions Department, who had great facilities for obtaining the necessary materials and packing the composition. This was the Geake flare, first seen by representatives from G.H.Q. in March, 1918, when the O.C. Experimental Section attended the trials at the M.I.D. The flare reached a range of 400 yards and was fairly accurate, and it had a percussion mechanism. The same difficulties were met with in its production in quantity by manufacturers as with the Geake message-carrying rocket (to be described later), both being on similar lines; and it was not until March, 1919, that it was recommended for introduction into the Service after satisfactory trials at G.H.Q., France.

In October, 1917, a suggestion was received from the Third Army to use a 3-in. Stokes mortar bomb filled with Very cartridges for illumination purposes, and this suggestion was transmitted to the War Office. For signalling purposes, timed as it was to burst in the

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air, the bomb was satisfactory, and was developed in England by the C.W.D.; but for illumination purposes the stars did not burn sufficiently long, and the C.W.D. experimented with a Stokes bomb filled with flare composition. Delay, however, occurred and the bomb was never satisfactorily developed. The Ministry of Munitions was continually pressed to produce the article, but the difficulty appeared to be that the composition could not be made up to be really safe to fire, as it frequently detonated on shock of discharge. It could be rendered safe for firing by the use of oil, but this increased the time of burning, and the smoke emitted was too dense. In November, 1918, it was reported to be impossible to eliminate the smoke; and, as this was a highly disadvantageous feature, the matter apparently dropped, and no further developments came before the notice of the Experimental Section. The difficulty of causing the bomb to light up with sufficient rapidity was also never properly overcome.

The development of the 1-in. and 1½-in. illuminating cartridges, to fire from the rifle, is described under "Signals," as the stars were used for both purposes.

## CHAPTER 4.—SIGNALS.

The history of the early days of firework signals is so closely connected with the history of "flares" that it is necessary to repeat a certain amount of what has been said already under that head.

Very pistol lights were used for illumination purposes, and also for signalling.

White, green and red stars were chiefly used right up to the end of the war. For a long time two sizes of pistol—1-in. and 1½-in.—were in use, but the 1½-in. was ultimately done away with on the recommendation of a Signal Conference held at G.H.Q. in December, 1917. The 1½-in. pistol in a cut-down form was, however, retained for the Cavalry Corps, as referred to later.

Similarly, various types of rockets and mortar signals, of which the illuminating patterns are described under "Flares," were tried from time to time. The types available at the beginning of 1916 were as follows:—

| *Designation.* | |
|---|---|
| 1. (*a*) Shells 5-in. daylight signal—Red. | Red smoke with white stars. |
| (*b*) Shells 5-in. daylight signal—Blue. | Blue smoke with white stars. |
| These were fired from 5-in. paper mortars. | |
| 2. (*a*) Flares yellow. | Yellow smoke only. |
| (*b*) Flares, electric ignition. | |

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| *Designation.* | |
|---|---|
| 3. Rockets, signal ½-lb. (or 1-lb.)—Blue (or Red, or Green, or Service.) | The 1-lb. rocket contained 49 stars and the ½-lb. 30 stars, Blue, Red or Green. |
| 4. Light long, Red (or Green, or G.S.) | Lasted about 5 minutes—held in the hand—friction ignition. |
| 5. Rockets parachute Large Special—Red (or Green, or White) | Red, white or green stars floating for about 2 minutes. |
| 6. Rockets parachute with coloured stars—Green (or Amber, etc.) intermingled with gold and silver rain. | |
| 7. Rockets parachute with coloured stars—containing 5 stars which change colour. | |
| 8. Shells, Daylight, Japanese, 4-in. | On bursting, liberated figures of animals, etc. |

Rockets were satisfactory as far as the signal was concerned, but they were unwieldy to handle and fire, and the trail was objectionable. Mortar signals were preferred and developed, and early in 1917 the 3-star parachute signal was made up in England and tested with satisfactory results. The idea for the design of this signal was taken from the French, and the Ministry of Munitions was asked to arrange for their manufacture late in 1916. Samples were made up by the Chemical Warfare Department and sent to France, and various combinations of colours were tried. Only mortar signals were sent at the time, but these signals were very favourably reported on in May, 1917. The rifle grenade signal with similar coloured stars came out later, and a large demand arose for it at once, as it was found to be a handier article than the mortar signal.

Trials were carried out in July, 1917, to determine which patterns should be eliminated, and which adopted, and very thorough tests for visibility were conducted with a large number of combinations of colours. As a result of these tests the War Office was informed that :—

(i) In 2-star and 3-star signals the colours yellow and white should be avoided, as they are easily confused with green and with each other.

(ii) In " changing colour " signals the first colour should not be white, as, if it is, the signal might be mistaken for an ordinary

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Very light, and in consequence might not be under observation when it changed colour.

(iii) Twelve feet is not a sufficient distance between stars in either 2-star or 3-star signals.

(iv) The possibilities of a signal which changes colour twice were worth consideration.

Samples of the following sixteen signals were requested for trial in France :—

(*a*) *Rifle grenade signals with parachute and hanging stars.*

Red over red
Red over green
Green over red
Green over green
} At least 20 ft. between the stars.

(*b*) *Rifle grenade signals, changing colour.*

Red to white.
Green to white.
Red to white to red.
Red to white to green.

(*c*) *Cartridges signal, 1½-in. with parachute and hanging stars.*

As (*a*).

(*d*) *Cartridges signal, 1½-in., changing colour.*

As (*b*).

In addition to these types, experimental signals with coloured smoke (red, blue, yellow or purple) were received during the autumn.

In December, 1917, a conference which included representatives from all armies was held at G.H.Q., when the whole question of firework signalling was investigated. The conclusions arrived at by this conference may be summarized as follows :—

(A) Mortar signals were inferior to rifle grenade signals.

(B) Signals with hanging stars should consist of three stars all of the same colour—reds, greens and whites suggested.

(C) Rifle grenades with red smoke should be retained as an alternative to (B) by day.

(D) Changing colour stars acted very well, but yellow could be dispensed with—" white to red and back to white," and " red to green and back to red " recommended for adoption.

(E) The 1-in. Very pistol should be retained for illuminating purposes chiefly. The 1½-in. Very pistol should be discarded, except a small number for the Signal Service.

(F) Flash signal for the Signal Service for use in combination with visual required.

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(G) Also the Signal Service required a special signal in the form of a 1½-in. cartridge bursting into white stars, and designed to illuminate the ground as little as possible.

(H) A Stokes mortar bomb adapted to discharge a shower of coloured lights at a height of about 600 ft. Required as a special signal for use in special operations.

With the development of the discharger, the rifle grenade signal was adapted to fire from it, and this replaced the rodded grenade signal. After much work by the Experimental Section a suitable pattern was evolved; it is illustrated in *Plate* XI, and was called the No. 43 Signal. Supplies were submitted and tested in France in the autumn of 1918, and were passed as satisfactory.

As before mentioned, a special signal fired from the 1½-in. Very pistol was used by the cavalry. The bursting charge of the signal was reduced, so that it could be fired from the 1½-in. pistol held in the hand with the butt removed and the pistol barrel cut down in length; and the weapon was carried in a leather case slung round the shoulder. The signal consisted of a suspended star which changed colour from green or red to white. This signal was not entirely suitable for cavalry work, in which it was required mainly for indicating locality; as it had a parachute it was soon blown away from the correct position in a wind, and the actual locality from which it was fired became difficult to determine. It was, however, used up to the time of the Armistice.

Signals were always the source of much experiment by troops, and one suggestion, received in February, 1918, which was developed, was to fire a 1½-in. Very cartridge from the rifle by the addition of a rod and empty S.A. cartridge case soldered to the base.

Both the illuminating star and the illuminating floating star patterns were made up in this way, and the Experimental Section made about 1,000 for issue to armies for trial. A little later, as a result of experimental work with the discharger, it was found that the 1½-in. and 1-in. illuminating star, though of sensitive composition, could be fired from the discharger with a ballistite cartridge if correctly arranged with felt wads for a cushion. A simple device was worked out and 900 of these were made up (300 each, red, green, and illuminating) for issue to armies for trial. Actually no issues were made owing to the Armistice, but sufficient tests had already been made to show that it was a very simple way of firing the cartridge, and would entirely do away with the 1-in. and 1½-in. Very pistols.

Experiments were continually being carried out in England to improve the ingredients of all signal compositions and produce other colours. A green smoke was experimented with but never materialized, also a blue light, but this colour was too

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dangerous to manufacture on account of the fumes given off in mixing.

As regards the special signals asked for by the December, 1917, Conference. The experiments in England with the Stokes mortar types (H) are described under "Flares"; the mortar shell, filled with red and green or white stars, proved to be a very fine signal, but was not developed by the C.W.D. till late in 1918.

For the Signal Service signals, a flash signal made up by the Experimental Section was considered quite suitable for (F) when it was developed after experiment. It consisted simply of a 1½-in. Very pistol cartridge filled with loose aluminium flare composition which, when lit on the ground with a time fuze, projected a bright flash into the air, the cartridge case acting as a mortar. Sufficient quantities, however, could never be obtained from the C.W.D. to give it a trial by armies before the war ended. A flash signal, brought out to France at the time of the conference, consisted of a S.A.A. cartridge filled with flare composition and fired from the rifle. This, however, was not only highly dangerous, but affected the barrel, as the heat developed was too great. Other types placed on the nose of the rifle, and filled with the same composition, did not develop, as they were not satisfactory and were dangerous.

A signal for survey purposes, copied from the description in a captured German document, was called for in August, 1918, and the Experimental Section took the matter up with the M.I.D. in England. After some trial a good signal was produced, but was not in time to be used during the war. It is understood to have been supplied after the Armistice and used for survey purposes. It consisted simply of a tube of flare composition fitted with wings, which was fired from the discharger, and carried a set-back mechanism in its head similar to the rodded rifle grenade signals. It gave a flare as it was projected through the air, and by triangulation with the theodolite from different stations is believed to have proved a useful signal for location of forward positions. In the original German instructions it is described as being a "vertical light-ray" for employment :—

(i) In fixing points during trench warfare.
(ii) In fixing the position of survey posts during mobile warfare.

The O.C. of the Experimental Section was frequently called upon to advise in connection with signals for the Royal Air Force.

Ground flares were used, as previously explained, for Aeroplane-Infantry contact work and, though generally favourably reported on, were not entirely satisfactory. The chief outstanding objection to their use in this connection was the amount of smoke they emitted while discharging their coloured lights. They were used in vast quantities by the infantry to indicate in daylight their positions to

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their aeroplane contact patrols, and the smoke emitted by them disclosed their position to observant enemy artillery officers from a considerable distance off. They were superseded eventually by the introduction of a white canvas cover attached to the gas mask haversack, which, when waved by the infantryman, could be fairly easily picked up by the aeroplane observer. Before this, the Experimental Section had made up various forms of fans of ingenious design for the same purpose, but these were discarded in favour of the gas mask flap.

In December, 1917, the Experimental Section was called upon to devise something entirely new in the way of flares for use by aeroplanes to call up the infantry. Something quite distinctive had to be designed which could not possibly be confused with the various signals and flares already in use by infantry and other arms. Several methods were tried in competition with suggestions from other sources. The Section made up large paper parachutes of various colours which could be fairly easily seen, but were not found sufficiently distinctive for the purpose.

Paper concertinas in the form of streamers about 10 ft. long were quite invisible. The flare which was unanimously adopted, and considered by most observers to be the most striking signal ever produced, was the 16 smoke-ball flare. It consisted of 16 smoke balls in two compartments of 8 each. In each side were 4 balls of purple smoke to be seen on bright sunny days, and 4 yellow for dull days when the purple could not easily be seen. The flare was made up in a tin case with a special lighter, both illustrated in *Plate* XII. It was also made up to be fired from the R.L. tube electrically.

The hand pattern was the one preferred and was fitted with a 3-sec. fuze, the lighter being started by the observer pulling the top ring, when the flare dropped and burst below the aeroplane. (See *Plate* XII.)

Eight stars were discharged in one direction and eight in the other, and fell through the sky in the form of long fingers. When thrown from a low altitude (below 800 ft.) they appeared to fill the sky, as the balls emitted trails of smoke till they almost reached the ground, when they went out.

The flare was introduced and manufactured in large quantities, but supplies did not begin in France till about the period of the Armistice. Smoke parachute signals, as used by the infantry, were made up to be thrown from aeroplanes, and also Very pistol smoke parachute flares; but none of these could be compared with the 16 smoke-ball flare.

A Table is appended showing the heights of burst of the principal British signals.

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TABLE SHOWING THE HEIGHTS OF BURST OF THE PRINCIPAL BRITISH SIGNALS.

| | |
|---|---|
| Rockets, 1½-lb. parachute ... ... ... ... | 413 ft. |
| ,, 1-lb. stars ... ... ... ... ... | 402 ,, |
| Rifle grenade signals, 2 stars ... ... ... | 308 ,, |
| ,, ,, ,, 3 ,, (new type) ... | 307 ,, |
| ,, ,, ,, 3 ,, (old type) ... ... | 252 ,, |
| Mortar signals, 3 stars ... ... ... ... | 230 ,, |
| ,, ,, smoke ... ... ... ... | 205 ,, |

*Cartridges for Very Pistol.*

| | |
|---|---|
| 1-in. illuminating ... ... ... ... ... | 404 ,, |
| 1-in. signal ... ... ... ... ... ... | 246 ,, |
| 1½-in. illuminating ... ... ... ... ... | 511 ,, |
| 1½-in. parachute illuminating ... ... ... | 244 ,, |
| 1½-in. signal ... ... ... ... ... ... | 322 ,, |
| 1½-in. signal, changing colour, parachute ... ... | 193 ,, |
| 1½-in. smoke ... ... ... ... ... ... | 248 ,, |

## CHAPTER 5.—SMOKE-SCREEN PRODUCERS.

A demand for smoke arose in 1915, soon after the first gas attacks by the Germans.

It was required for two different purposes :—

(*a*) As a dense cloud for the purpose of forming a screen.

(*b*) To simulate a gas cloud.

About July, 1915, smoke cases or candles were obtained privately by one corps from Messrs. Pain & Co. These were used to set up a smoke-screen, and after a few had been purchased, the War Office was asked to send out a number for trial, and further enquiries were made in England for a similar article to produce a denser screen.

Smoke candles were manufactured during the summer as fast as Messrs. Pain could turn them out, and at the same time "P" bombs and bombs filled with a mixture known as threlfalite were also sent out from England.

The smoke candle consisted simply of an 8-in. case filled with smoke mixture, with a hole at one end and a tape friction lighter. The average candle weighed 1½ lb. and burned for four minutes at the most.

It was soon found that these candles did not produce a sufficiently dense screen unless used in extraordinarily large numbers, and a better effect was obtained by the use of red phosphorus spread out in trays—2 lb. every two yards, which lasted for one hour.

A local smoke producer was made up in one army from a mixture of pitch, nitre, tallow and gun-powder; and several hundreds of

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these were used to supplement the supply of " P " bombs and smoke candles.

The next development was the use of the 4-in. mortar to fire smoke shells so as to put up a screen over the enemy trenches.

The 2-in., 3·75 mm. and Stokes mortars were also used for this purpose during the winter of 1915–1916, when demands went on steadily increasing.

Up to the beginning of 1917, the following patterns and types had all been tried :—

" P " bomb (red phosphorus).
Fumite bombs (yellow phosphorus).
Smoke cases (Messrs. Pain).
Threlfalite No. 1, and threlfalite No. 2.
Realgar (red phosphorus).
Pelagus mixture.

*Weapons Firing Smoke Projectiles.*

9·4 mm. mortar.
3·75 mm. mortar.
4-in. Stokes mortar.
3-in. Stokes mortar.
2-in. mortar.
Trench catapults.
" P " bomb rifle grenade.
No. 27 and No. 37 smoke rifle grenades.

Of all these, only the " P " bomb and the Pain smoke case (known later as the " S " case), survived at the end of the war, and among the weapons for firing smoke projectiles the Nos. 27 and 37 grenades and the 3-in. mortar.

Manufacture during 1917 and onwards was concentrated on these, and many millions of the smoke producers must have been made.

The Experimental Section was chiefly concerned in the development of the " P " bomb and No. 27 grenade, as well as in experiments with the Pain smoke grenades and local smoke producers.

In the summer of 1917 a smoke case was made up by the Section to supplement the supplies from England.

This was a very simple type, and required nothing but material available from Ordnance. The usual mixture consisted of 8 parts powder, 6 pitch, 1 tallow and 1 sawdust, and was filled into an empty 18-pdr. shell case. Sometimes tallow was omitted, and the mixture was then gun-powder 5 lb., pitch 6 lb., sawdust ½ lb.—this quantity being sufficient to fill two 18-pdr. cases. Manufacture was mainly undertaken for the coastal operations of the Fourth Army.

About the same time it was found that the Germans were using

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a smoke-producing machine for the purpose of concealing battery positions, concentration of troops, etc.

This machine consisted of an iron drum in which chloro-sulphonic acid and quicklime were contained in separate compartments, and when the acid was allowed to drip on to the quicklime a dense smoke cloud was produced.

Experiments were carried out to try and produce a similar result by means of the Experimental Section mixture used in larger cases, but this was never satisfactory, as, when used in large quantities, the mixture was always liable to burst into flame, and to burst open the case. Continuous experiments were carried on in England to develop large phosphorus generators, but were never really successful.

The Navy had produced a satisfactory generator (pitch), but it was required in such large quantities for anti-submarine warfare that none could be spared for France.

At the beginning of 1918 experiments were carried out with a container of chloro-sulphonic acid fitted to a motor-car, the acid being allowed to drop in the exhaust of the car; and good results were obtained by the Tank Corps in this way. Fitted to a light car, however, results were poor; but experiments were carried on for some time with lorries. Although the method had not come into regular use before the end of the war, there were distinct possibilities in the idea. It was found that the best results were obtained under the following conditions :—

(*a*) That the pipe leading from the generator to the exhaust should enter the exhaust pipe at the point of maximum heat, *i.e.*, just below the outlet from the rear cylinder into the main exhaust pipe, care being taken not to allow the acid to drip or work through into the cylinder.

(*b*) That the exhaust should be fitted with a branch outlet for the smoke, thereby cutting out the silencer; or the silencer removed altogether.

(*c*) That the moisture of the petrol vapour should be augmented by means of a water spray introduced into the pipe, and heated up so that if possible the water was condensed in the pipe.

Under these conditions a good smoke cloud was produced, and a drum containing about 10 gallons would last for half an hour. The acid had a tendency to choke the pipe, and it was necessary to run the engine until all the smoke died away, in order to clear the pipes.

The better results obtained by tanks were probably due, firstly to the higher power of the engine, and secondly to the fact that the engine itself would be running at full speed under a load. The tank, of course, need not necessarily be stationary to produce the smoke cloud, but a car or lorry engine would not be working under load

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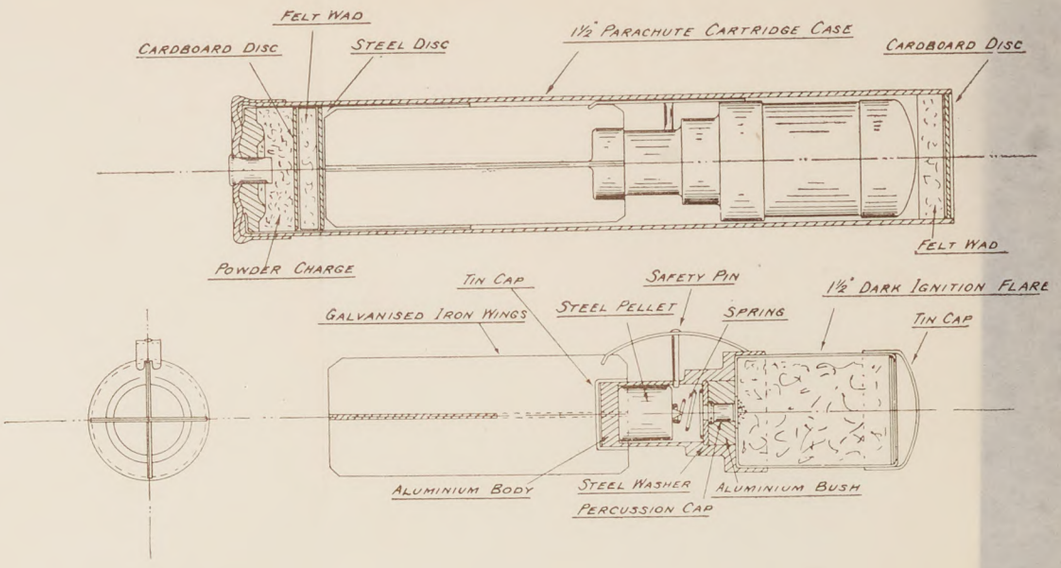
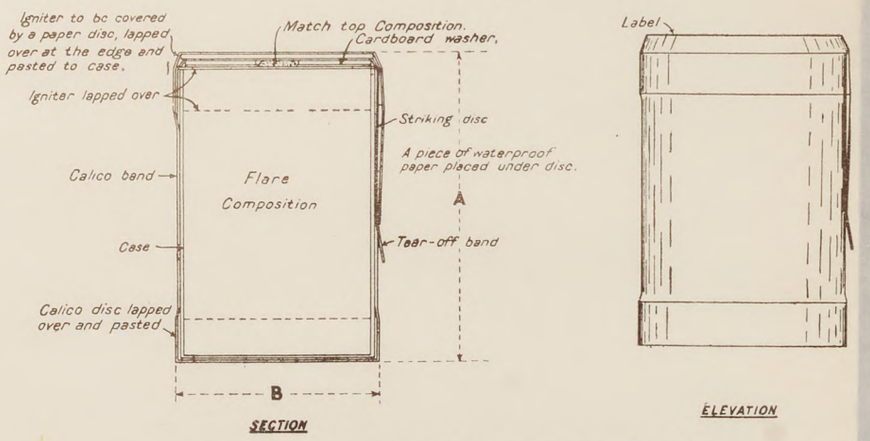
Fig. 1.

## THE GRIFFIN PERCUSSION FLARE.




## FLARES, GROUND, /L/.

### TYPICAL




| DIMENSIONS A | DIMENSIONS B | Mark | Colour of Flare |
|---|---|---|---|
| 3" | 2" | 1 | Red, Green, Yellow, White |
| 1¾" | 2" | 1 | " " |
| 1½" | 2" | 1 | " " |
| 1½" | 1½" | 1 | " " |

Fig. 2.

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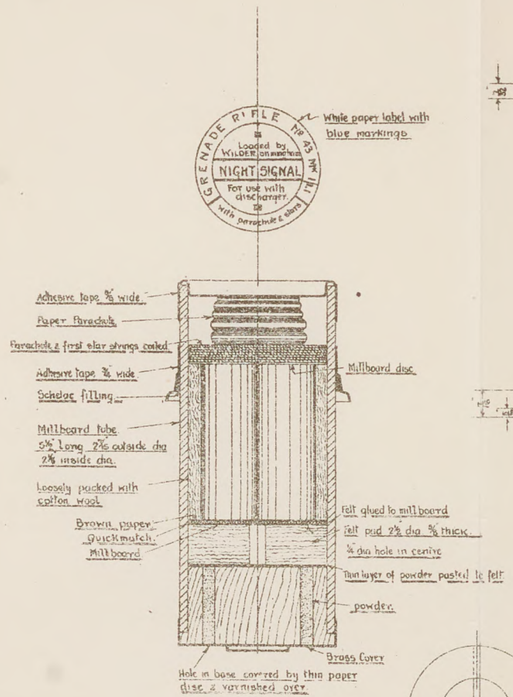
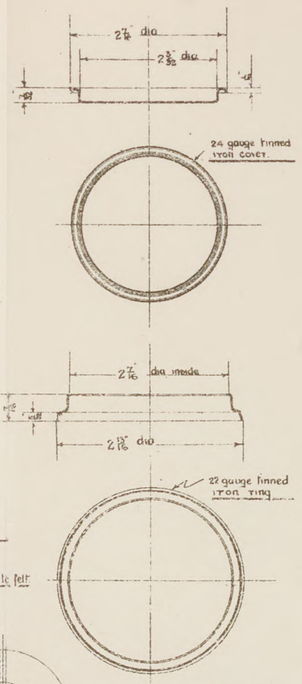
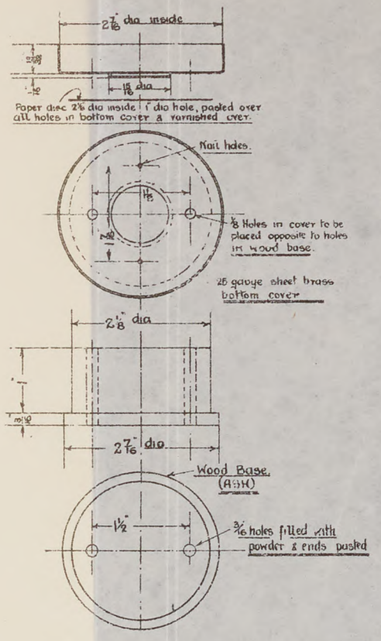
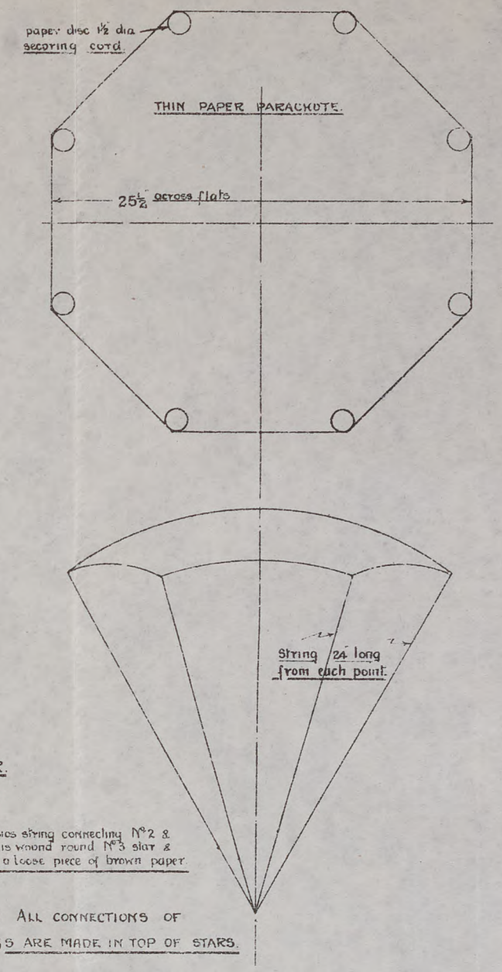
# ARRANGEMENT AND DETAILS OF No 43–3 STAR PARACHUTE RIFLE DISCHARGER SIGNAL. PLATE XI


GRENADE RIFLE
Loaded by WILDER on machine
NIGHT SIGNAL
For use with discharger
With parachute & stars
White paper label with blue markings
Adhesive tape ⅜ wide
Paper Parachute
Parachute & first star strings coiled
Adhesive tape ⅜ wide
Schelac filling
Millboard tube 5¼ long 2⅛ outside dia 2⅛ inside dia.
Loosely packed with cotton wool
Brown paper
Quickmatch
Millboard
Millboard disc
Felt glued to millboard
felt pad 2⅛ dia ⅜ thick
¼ dia hole in centre
Thin layer of powder pasted to felt
powder
Brass Cover
Hole in base covered by thin paper disc & varnished over





2⅛" dia inside
⅛
1⅛ dia
Paper disc 2⅛ dia inside 1" dia hole, pasted over all holes in bottom cover & varnished over.
Nail holes.
⅜ Holes in cover to be placed opposite to holes in wood base.
25 gauge sheet brass bottom cover
2⅛" dia
2⅞" dia
Wood Base. (ASH)
1½"
⅜ holes filled with powder & ends pasted



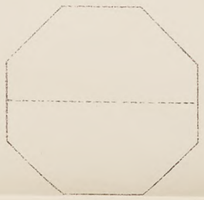



Fig 1.
Parachute laid flat

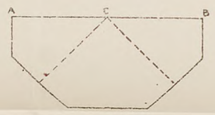
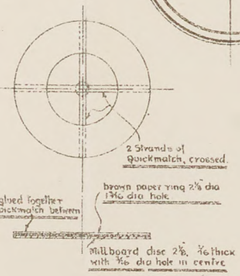
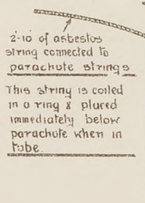
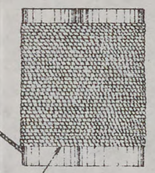


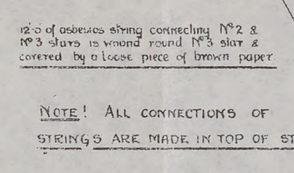

Fig 2.
Folded across centreline
Shewn dotted in Fig 1.

Fig 3.
Corners A & B (Fig 2) folded forward until AC & BC become vertical


2 Strands of Quickmatch, crossed.
brown paper ring 2⅛ dia 1⅜ dia hole
discs glued together with quickmatch between
Millboard disc 2⅛ ⅛ thick with ⅜ dia hole in centre.


No 1 STAR (GREEN)
2·10 of asbestos string connected to parachute strings
This string is coiled in a ring & placed immediately below parachute when in tube





No 3 STAR (GREEN)
12·0 of asbestos string connecting No 2 & No 3 stars is wound round No 3 star & covered by a loose piece of brown paper

NOTE! ALL CONNECTIONS OF STRINGS ARE MADE IN TOP OF STARS.

12·0 of asbestos string connecting No 1 star to No 2 star is wound round No 2 & 3 stars COMMENCING at bottom

Fig 4.
Corners D & F (Fig 3) folded forward until ED & EF become vertical.

Fig 5.
Triangle GHJ (Fig 4) to be folded behind triangle GHK

Fig 6.
Triangle LMN (Fig 5) folded across remaining portion

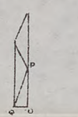



Fig 7.
Triangle OPQ (Fig 6) folded across front.

Fig 7. Folded forwards & backwards with apex at top. (Rectangle 1⅜ · 1½)

DIAGRAM SHEWING METHOD OF FOLDING PARACHUTE.

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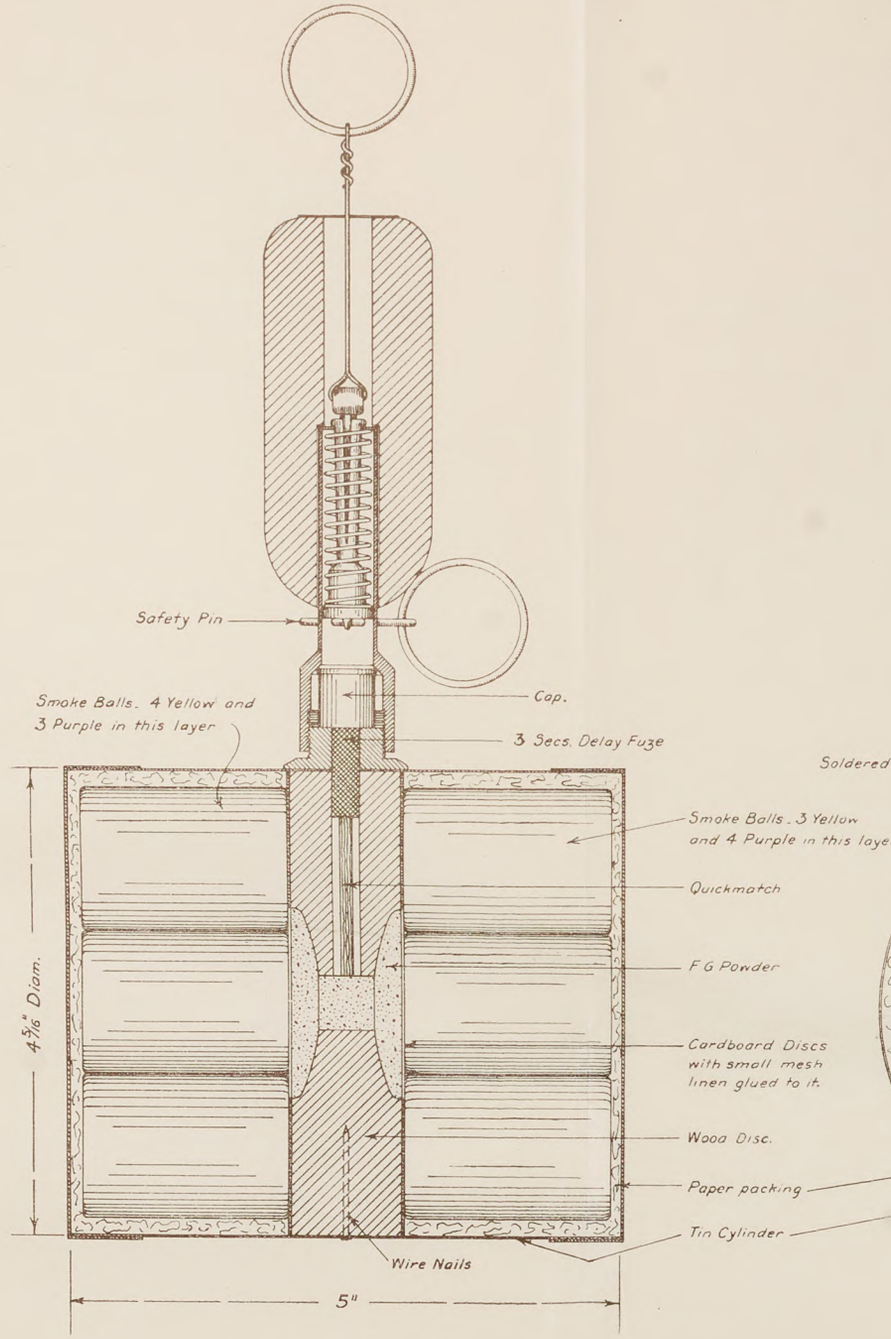
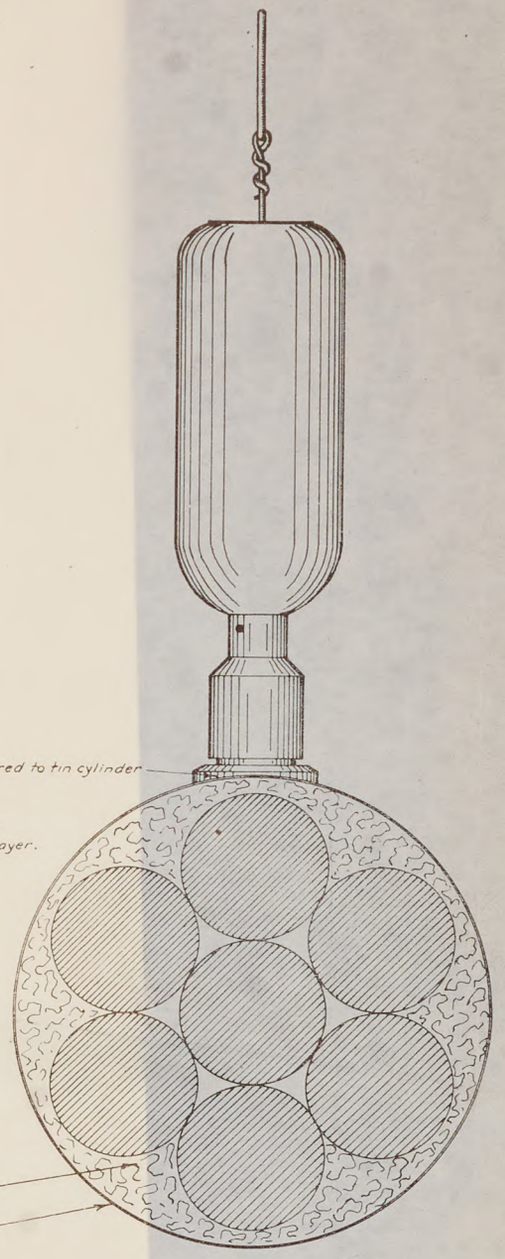
# PLATE XII.

R.A.F. PURPLE AND YELLOW SMOKE BALL INFANTRY CONTACT SIGNAL WITH SPECIAL R.A.F. IGNITER.




SECTION.




CROSS SECTION.

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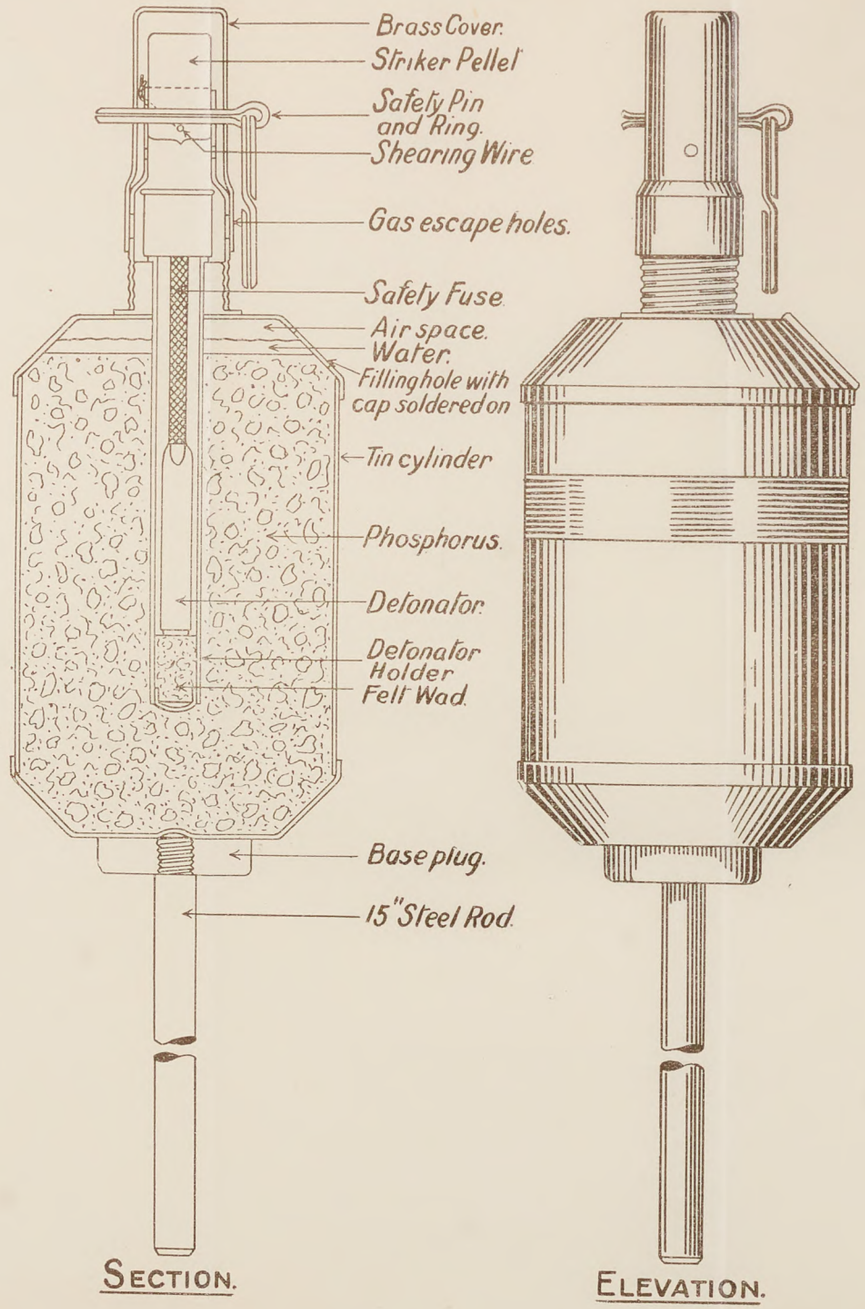
Fig. 1.

RIFLE SMOKE BOMB, No. 27.



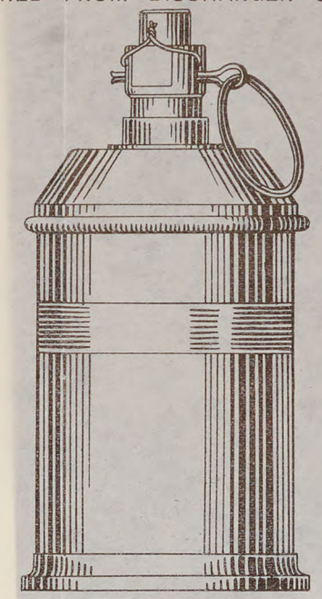

SECTION.

ELEVATION.

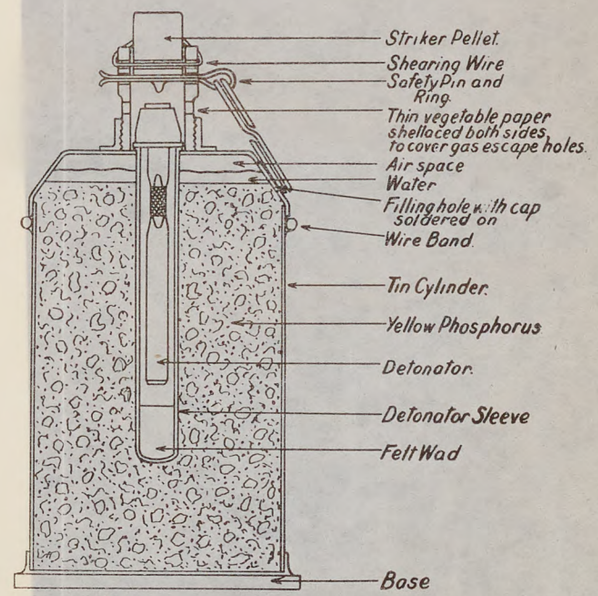
Fig. 2.

RIFLE SMOKE BOMB, No. 37.

FIRED FROM DISCHARGER CUP.



ELEVATION.




SECTION.

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unless the vehicle was travelling at too fast a pace for the formation of a proper cloud.

### Smoke Rifle Grenades.

The No. 27 smoke grenade was developed by the Experimental Section from an incendiary grenade used by the French. The French grenade was made of tin, and filled with yellow phosphorus; it was fired by a time fuze, with a "hit" mechanism, from which the idea of the "hit" mechanism of the Egg grenade was taken. Exhaustive experiment was carried out with this French phosphorus grenade, and finally resulted in the Nos. 27 and 37, which were manufactured in large quantities in England. Before the production of the No. 27, the "P" bomb had been converted to fire from the rifle, but was never satisfactory, being too heavy, and not constructed for that purpose. A good many, however, had been adapted, and various patterns of base for it were manufactured in army workshops.

It has already been mentioned that the original "P" bomb was filled with red phosphorus, which was not a good smoke-producing substance for use on ground over which infantry were to advance, as it remained burning on the ground for a long time, and would injure men who fell on it. In the improved patterns, both for hand and rifle use, yellow or white phosphorus was used.

Any form of phosphorus grenade had disadvantages when thrown by hand, for the phosphorus was always liable to be blown back by enemy artillery fire; and also the radius of spray on bursting was too great; with the No. 6 detonator the average radius was 20–25 yards, and in a wind, up to 30 yards, *i.e.*, practically the maximum distance of throw. After considerable experiment, the use of the No. 6 detonator was given up with these grenades, and the No. 3a commercial detonator introduced in its place, which considerably reduced the radius of burst. Trouble always existed with the firing mechanism in the field, because, when the grenade fell (especially when firing from the rifle) on hard ground, the whole mechanism was apt to be knocked off, carrying the detonator with it.

Similar trouble was experienced with the first supplies of the No. 37, which was the same grenade, adapted for firing from the discharger.

The final patterns of No. 27 and No. 37 smoke grenades are shown on *Plate* XIII.

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# *SOME NOTES ON CENTRAL CANADA.*

*By* MAJOR-GENERAL J. A. FERRIER, C.B., D.S.O.

CANADA is crying out for population, preferably of Anglo-Saxon descent, to occupy her vast unsettled territories, and promises immigrants a prosperous and healthy existence, assured livelihood, and a future of reasonable comfort to themselves in their old age and a career for their children.

It seems advisable to enquire into the present economic state of the country to ascertain whether Canada is really in a position to hold out these inducements to immigrants, which are undoubtedly made in good faith, and estimate for ourselves whether she is able to fulfil what she undertakes to do.

In the first place Canada holds out her invitation to people who are capable of engaging in agriculture and willing to go on the land. All others, though no doubt they would be made welcome, are not so desirable, from her point of view, for meeting her immediate needs.

It behoves us of the Old World to remember that the attitude of the men who have left the land of their birth to seek a world of wider expansion across the Atlantic, is one of hopefulness, not to say optimism.

The man who sets out to describe the whole of Canada is undertaking an impossible task. If he has devoted many years to travelling over the country, and has passed the four seasons in each district, he will find that the information first collected is ancient history, and conditions will have been rapidly changing while his investigation is still in progress. So, necessarily, a great deal of second-hand information has to be accepted and duly weighed by the light of what he has seen for himself. What follows is confined to what may be called Central Canada.

The Province of Ontario, comprising as it does within its borders the central seat of Government, naturally attracts a large proportion of the men who are in a position to express a reliable opinion on the conditions prevailing in the Dominion, as a whole: it has intimate connection racially and economically with the Province of Quebec, and Manitoba is not far off in the opposite direction.

The climates of Quebec and Manitoba are not altogether dissimilar in point of temperature. Both have very cold and long winters and hot summers. But Quebec has the inestimable advantage of a long riparian tract bordering on the shores of the St. Lawrence estuary: these districts have a somewhat less severe winter and the summer heat is tempered by sea breezes.

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Southern Ontario, lying in between and bordering on the Great Lakes, has a considerably milder winter than its neighbouring provinces.

Northern Ontario, up away north of the Transcontinental Railway, and extending up to the Hudson's Bay, has little to choose in point of climate between itself and its neighbours.

It is unlikely that it will become a suitable area for permanent agricultural settlement for many years to come, though mining centres and lumber camps may be formed in certain localities when the development and population of the Dominion have so far advanced as to make the exploitation of the mining and lumber resources a paying proposition.

It is a great forest area, with a wealth of useful timber and inferior lumber suitable for conversion into pulp for the ever-increasing pulp wood industry.

The economic conservation of this store-house of wealth lies rather in its protection from forest fires than from the clearing of its timber for farm lands, and the Forest Department is already alive to the advantages to be gained from efficient patrolling and re-afforestation.

What is said above about the forests of Northern Ontario applies equally to those portions of Northern Quebec that afford the winter occupation of the farmers of the Province.

The French-Canadian has hitherto held the reputation of being the prince of lumbermen, and at Grand'Mère there is a model lumber organization that provides for re-afforestation and really scientific forestry.

A few words about Manitoba, the great prairie province with the flattering reputation of being an immense granary. Its capital, Winnipeg, may be said to be the clearing house of all the grain in the West as far as the Rocky Mountains.

This area is practically all prairie land. It has attracted a large number of farmers from the United States, and for many years its rate of production of wheat was prodigious. But latterly there has been a considerable falling off, and where many years ago farmers counted on 40 bushels to an acre they have now to content themselves with 18 or even 12 as an average.

An undoubted disadvantage of Canada is the severity and length of the winter season. Its duration may be taken to average six months: its severity may be gauged by the following figures taken from the tables published by the Dominion Meteorological Service, Toronto.

Average number of days zero (Fahrenheit), or below, for period 1916–1922 :—

| | | | |
|---|---|---|---|
| Toronto | 8 | ... } | Southern Ontario. |
| London | 11 | ... } | |
| Ottawa | 37 | ... | Eastern Ontario. |
| Haileybury | 55 | ... | Ontario. |
| Winnipeg | 69 | ... | Manitoba. |

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The highest and lowest temperatures recorded are :—

| | | |
|---|---|---|
| Toronto ... ... | 103° | —26° |
| Haileybury ... | 102° | —48° |
| Winnipeg ... ... | 103° | —46° |
| Montreal ... ... | 95° | —26° |
| Quebec ... ... | 96° | —34° |

There is no necessity to insist on the severity of the climate, and it will be readily understood that the housing problem is not quite so simple as what we are accustomed to in the British Isles and in Europe generally. The heating arrangements in particular call for special care, as the risk of frost-bite is not to be run with impunity, let alone the freezing of water pipes with attendant discomfort.

So housing, room for room, costs a good deal more than in this country, and the coal bill forms a considerable item in the family budget.

Canada has, according to the latest returns available, 39,384 miles of standard-gauge railway, or one mile to every 215 head of population. These lines are working to the full capacity for only part of the year, and in many districts the Canadian Pacific lines and the Canadian National Railway lines work practically side by side, an uneconomic arrangement that has no advantage in any way, as the traffic rates are under Government control. It is hoped that the Government may see its way to scrap many hundreds of miles of redundant railway and so save the annual deficit on the working of the State-owned system.

The busy season is after the harvest, when there is a steady stream of wheat traffic running eastward from Winnipeg and Toronto. Any wheat that there may be for export west of the Rockies naturally takes a westward course, and it is even said can be profitably brought through the Panama Canal to European markets.

When the Transcontinental Railway was pushed across the continent, some years ago, the scheme was for a ruling grade of ·6 per cent. westward from Winnipeg to Prince Rupert and ·4 per cent. eastward to the Quebec Bridge. The War intervened : the land has not been settled to the extent that was estimated, and so the corn traffic has not come up to expectation.

Recent developments in Quebec and Ontario Provinces have taken the form of trunk roads, and an enormous increase of industrial activity. This trunk road policy is extending over the prairie provinces, and takes the form of substituting for the gravel or water-bound macadam roads of pre-war days somewhat ambitious motor roads, 24 and 30 feet wide, surfaced with bitumen on a macadam base. The roads in the cities and townships are as a rule built of concrete with a surfacing of bitumen. Sidewalks in the cities,

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which before the war were made of old sleepers, are now replaced by concrete slabs.

Whereas before the war Hamilton was looked upon as the Birmingham of Canada, and there were a certain number of factories at Peterboro', St. Catherine's, London and Kitchener in Ontario, and at Montreal in Quebec Province, we now find a large number of factories in Toronto and Ottawa.

The development appears to be mostly in machinery, lumber and pulp mills; there are also some textile and woollen mills: but a reference to a Trades Directory discloses a number of enterprises, more or less of small extent, that have sprung up in recent years.

Whether the whole of these industries are Canadian-owned and financed by Canadian capital is a question that could only be answered by close investigation. But many of the firms are representative of parent establishments in the United States, and have probably been established on United States capital, and are often managed by citizens of the United States. However, they afford employment to Canadian workmen.

Trade, they say, is bad, and the results at present are disappointing. But it is open to doubt if there is sufficient field in a sparsely populated country for such an industrial expansion.

The public buildings in cities like Montreal, Toronto, Winnipeg and Ottawa are very fine indeed, and strike the stranger as somewhat palatial, considering the population catered for. It has to be borne in mind, however, that if a building in Canada is expected to last it must be solid. The walls must be thick to keep out the cold in winter and to conserve the artificial heat. The foundations must be deep, and a basement is a necessity to accommodate furnaces, coal storage and other accessories: it is, moreover, a protection against damp and cold rising from the ground. If anything should happen to the water-circulation system there are no fireplaces or stoves to act as substitutes for the central heating. Wherever one goes one is confronted with this heating question, and there is very little doubt that it is one of the ruling factors in the future prosperity of the country.

Municipal services in the cities and towns are very efficient, and great stress is laid on sanitation.

Street lighting on the whole is much in advance of what we are accustomed to in Europe.

Electricity is comparatively cheap and it is used lavishly. Too lavishly, for already there is a cry for more sources of electrical supply. The demand is specially acute in Ontario, where the Hydro-Electric Commission of the Province is straining every nerve to supply the ever-increasing demands for power, light and heat. The latest proposal being to site the St. Lawrence River dam projected in connexion with the International Navigable Waterway in such a

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way that the requisite head of water may be obtained for generating the electricity so badly needed by the province. All that Niagara and Chippewa can supply is already used up.

Ottawa is well situated as regards water power. The province of Quebec has the call on many rapid streams, and the prairie provinces are not squandering their power in industrial enterprise.

But, taken all round, Canada must in the near future utilize every possible source of water-power or else she must scrap her industrial ambitions and restrict her supply of electricity to what is needed to keep her population from freezing in winter.

The natural question is: why not use their own coal? So they do. But it is soft coal, and burns away too rapidly, and fills the sky with smoke when used in the furnaces, which are designed for anthracite. Moreover, the transport of the coal to Ontario is not a paying proposition. Coal from the Maritime provinces finds its way by water to Montreal, and the Quebec province is more or less provided from this source. But when it comes to transporting Alberta coal to Ontario, it is going the same way as the grain traffic, and so its supply is precarious and the freight charge high. So anthracite is brought from Pennsylvania and costs in Ontario from $17 to $17·50 a ton of 2,000 lbs., say £3 16s. 6d. to £4.

A modest household of 4 to 6 persons calculates on using with economy 12 tons in a winter for heating alone. Cooking is mostly by gas, even the circulating hot water is heated by a gas coil. Actually last winter some people in Ontario found it economical to burn Welsh anthracite at £4 10s. a short ton on account of its superior quality, but the supply is limited.

The coal strike in the United States of some years back is still a poignant memory in Central Canada, and the risk cannot be run again. The way out is the difficulty.

There are many other causes that tend to send up the cost of living. House rent in the cities is very high. This is due partly to the cost of building, but more especially to the price of sites.

We consider £1 10s. to £2 per foot-run of frontage, 150 feet deep, a pretty stiff price in this country for a country site—this compares with $70 to $90 per foot for the last lot in a new suburb, 90 feet deep.

Then taxation. These are the taxes on a seven-roomed house in the outskirts of Toronto:—

| | | | | | |
|---|---|---|---|---|---|
| General tax ... | $109·72 | | Municipal tax ... | $19·13 |
| School ... ... | $52·75 | | City tax ... ... | $23·32 |
| | $162·47 | | | $42·45 |

Total $204·92.

As the landlord pays the taxes, such a house could not be let under $75 a month, say £180 a year.

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This scale of taxation appears to be more than a new country requiring development can stand. But high taxation means high rent, high cost of living, and consequently high wages, and so on in a vicious circle.

Now, food is not expensive in Canada. The prices compare very favourably with those in England. Meat is a good deal cheaper, but not quite so good; fish, dear and rather scarce; bread, slightly dearer; milk and butter, cheaper and exceptionally good. All the rest much the same as in England, except potatoes, which have to be bought in small quantities except in households with exceptional frost-proof storage.

A family man, unless exceptionally well off, expects to have his cooking done by his wife. Charwoman or washerwoman costs $2·50 and car fare per day. Both are supposed to have breakfast before they come, and the day's work ends at 5 p.m. Nevertheless, the dinner and two other meals may be reckoned as usual.

The domestic service problem is just as acute in Canada as elsewhere. Servants can be found, but they are expensive; so many people live in apartment houses, where service is provided, or else in hotels.

The average daily charge at hotels is $6 *per diem* for bed and breakfast. A modest lunch would cost $·75 and dinner $1·50.

Then why is the cost of living so high?

Canadians say that their standard of living is higher on the average than that obtaining in the Old Countries. This is no doubt true in a great measure; but can they afford it and still continue to progress?

The following figures may possibly throw some light on the subject. Extracted from the *Canadian Year Book*, latest edition :—

*Public Finance.*

| Years. | Revenue per head. $ | Expenditure per head. $ |
|---|---|---|
| 1907 | 10·71 | 8·18 |
| 1913 | 22·41 | 14·89 |
| 1918 | 31·31 | 21·41 |
| 1922 | 42·60 | 38·76 |

*Public Debt.*

| | |
|---|---|
| Balance sheet, March 31st, 1921— | |
| Gross Debt ... ... | $2,902,482,117 |
| Available Assets ... | $561,603,133 |
| Net Debt ... ... | $2,340,878,984 |
| Balance sheet, 1922— | |
| Total Debt ... ... | $2,902,347,137 |
| Assets ... ... | $480,211,336 |
| Net Debt ... ... | $2,422,135,801 |

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*Liabilities.*

| Funded debt payable in | | 1918. | 1922. |
|---|---|---|---|
| London | ... | $362,703,312 | $307,641,659 |
| Canada | ... | $881,528,614 | $2,002,215,601 |
| New York | ... | $75,873,000 | $110,934,000 |
| Total | ... | $1,320,104,926 | $2,902,347,137 |

It must be borne in mind that the Dominion took over the Canadian National Railways some few years back. We learn from *The Times* that the net revenue shown for 1922 was $2,480,000 and that for 1923 is $20,127,000, but these balances are struck before providing for interest charges or the service for debt.

Few will be found to question the statement that Canada's future prosperity depends on the development of its agriculture, timber and mineral wealth.

There are, therefore, four great industries in the Dominion—farming, lumbering, hydro-electric enterprise and mining—the last-mentioned being largely dependent on the third. But the greatest of these is farming.

How is it that we find in the census returns of 1910 Ontario's rural population to have declined by some 52,000 in the previous ten years? It is a matter of common talk that the rising generation will not stay on the farms. Ten years ago it was a subject of general comment that the young men were not content to remain on the farms in the eastern provinces and in Ontario, but all wanted to trek to the Far West. Now the talk is that they prefer to come into the towns and seek for " white collar " jobs.

A review of the 108 towns and cities ranging from a population of 5,000 to over 500,000 shows a total of 3,482,000, nearly 3½ millions out of a population of 8½ millions, who are dwellers in towns. Surely too high a proportion for a nation whose wealth is mainly in agriculture.

Is it that agriculture does not pay? Or does it not furnish a sufficiently rapid return in dollars? Or is it that life in the towns is more attractive? Now, the farmer says: I cannot make a decent living out of my farm so long as this high taxation is in force.

The rate of wages fixed by the citizen finds its way into the country districts, and the workman insists on town rates of wages.

The dweller in the city is the man who prices and trades the farmer's grain, and the farmer comes off second best. Seventy-five cents a bushel of wheat of 60 lbs. very soon dwindles down when it costs 20 cents to put it in the elevator at Port Arthur.

Why must all the grain be handled and carried immediately after the harvest? It would pay the farmer better to wait for the winter snows and utilize his horses for hauling the grain in the winter as he

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used to do before this frenzy for motor traction and expensive motor roads came into being.

On the other hand many farmers got rid of their horses and adopted machinery for all their farming operations. Now the fallacy of this wholesale scrapping of horses is beginning to be found out, and the horse is coming into his own again, and we hear more and more of mixed farming.

As a body, the farmers are against the extravagant development of the motor roads and are not in sympathy with the expansion and decoration of the cities, which they have neither the time nor the money to visit except under the compulsion of business necessity.

They argue that all this expense really falls on them, for it is incurred with borrowed money; hence increased taxation all round, which falls heaviest on them, as their industry is the mainstay of the country.

It seems there is a great deal of force in the farmers' argument.

The farmer has had three bad years: 1923 and 1922 have been good, but he had arrears to make up, and he has had to borrow money from the banks. So the bumper crops of last year had to pay their toll to the bank agent before the grain was stored in the elevator.

The farm worker most favoured by the spokesmen of the Dominion Government is the man with some agricultural training who hires himself out for a term to the established farmer with a view to learning local methods and conditions, so that he may make a success of a farm of his own as soon as he finds himself sufficiently well off to make a start.

The harvester may come from anywhere. Some 12,000 men went out from Great Britain in 1923. Many of these it was hoped would stay on the land and eventually become farmers. We learn from *The Times*, January 17th, 1924, "Between 7,000 and 8,000 settled down to work in the Dominion. About 2,000 left voluntarily to return home or to go to the United States, and 800 were sent back to England."

The writer happened to be crossing from Canada at the same time as some of these deportees, and had an opportunity of discussing their case with the official in charge. They were all men who had refused work that was offered to them. Of those who remained on in Canada, a large number went out to lumber camps and the Government found jobs for many in the cities, factories, etc. But there seems to have been some misconception as to the rate of pay and amount of employment to be expected on the farms.

The rate given was $4 a day and their keep for the harvesting, and $6 a day and keep for the threshing.

The harvesting lasts from 3 to 4 weeks on the average, and the

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threshing may be put at 3 weeks, say 18 days—an average man had therefore a prospect of collecting—

| | | |
|---|---|---|
| 24 days at $4 | = | $96 |
| 18 days at $6 | = | $108 |
| Total ... | | $204, say £46. |

After that he had to find another job, to last him for the winter.

At lumbering a man could get a wage varying from $15 to $25 per month and keep, according to capacity and the nature of the work he was put to. A tradesman working at his trade would of course get the market rate. It so happened that in 1923 building went on till well into the second week in December, and painters and decorators were at work at their trades in Toronto, Montreal and Ottawa up to 15th December. This was exceptional, and, as a rule, building trades are laid off from about the third week in November, and earlier further west and north, except, of course, in British Columbia.

Considering the harvester as a prospective emigrant, his first consideration must be how he is to pass the winter. If he can secure a permanent job on a farm, well and good; if not, he must do as the harvesters did last year, take what he can get.

It is idle to generalize, for there are many grades of work to be considered. It may be accepted, however, that a sober, willing man will not be out of pocket when the end of April comes round and he can reasonably expect to get a job.

Here a word of caution is advisable to the man without a trade. In the open market he will find himself up against the "Dago"—a generic term for seemingly all races from the South and East of Europe who are not French, Scandinavian or of the Teutonic race—who will work for 25 cents an hour and thrive on it.

If he drifts westward of the Rockies he is confronted with the Japanese market gardener and the Chinese restaurant keeper, waiter, etc.

There is still room for all, and a pessimistic note is out of place where a serious worker is concerned: but if a man expects to fill his pockets without earning his wages, he had better have fallen overboard on the voyage out. If he is going to hold a job down in Canada he must work and work hard, without shirking, and if the hours per day are more than eight, which is usually the case in summer, he must not squeal, for he will get no sympathy.

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# *THE CONCEALMENT OF FORWARD COMMUNICATIONS FROM THE AIR IN MOVING WARFARE.*

*By* CAPTAIN AND BREVET MAJOR B. C. DENING, M.C., R.E.

THE construction of forward communications was, at all times during the war, one of the chief tasks of Field Companies. Whether we care to look back at the mobile operations of 1914, or the long period of siege warfare which followed, or the months of slow movement in 1918, whenever an advance was in contemplation, it is almost true to say that forward communications were the only concern of Divisional R.E.

As regards the *concealment* of forward communications from the air, by the end of the war, both the necessity for concealment, and the methods for obtaining it were pretty generally understood. It is true that immediately prior to Ludendorff's offensive on the Lys in 1918, bridges were prematurely thrown, and gave away the attack, and it is probable that the Allies made similar mistakes at different times. But, on the whole, after 1917, engineers can claim that where surprises were not effected, the fault did not lie in their failure to conceal their communications.

Looking at the problem to-day, it is well to remember that the majority of the advances of the Great War were made after long periods of preparation. Thus, there was considerably more time and material available than is likely to be the case in the earlier stages of the next war with which to ensure concealment of forward communications.

The manœuvres carried out this year by the 1st Division in the Farnham–Odiham area gave an interesting example of the type of demand likely to be made on Field Companies in the way of forward communications. The manœuvres were planned to test, amongst other matters, the question of concealment from the air. The following is a brief description of the first day's operations as far as concerns the subject under discussion :

" The manœuvres were carried out in typical English country, with some woods, large fields bounded by thick hedges, some deep overgrown lanes and open main roads. The Air Force opposed to 1st Division was given reasonable air superiority and forced by air umpires to work under conditions approximating to those of war. During the first day's operations, the 1st Division (Blue), deployed two Infantry Brigades against a weaker (Red) Force. The weather was fine with visibility excellent. The Red

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Commander instructed his Air Force to locate the Reserve Infantry Brigade of the 1st Division and to determine upon which portion of the battlefield it was to be thrown in. During the early part of the day, the Reserve Brigade was concealed in woods on the right rear of the Divisional front. In the afternoon, the situation was such that it had to be moved up to relieve the left Brigade in line.

It thus had to move up and across the front. It left the cover of the wood, taking special measures to avoid being seen from the air. Battalions moved out one at a time, in single file, along the side of roads, without transport. This method of advance led to a very considerable extension of the brigade, and was very slow, the brigade taking close on three hours to pass a point. The advance might have been made more rapidly but for a river over which the crossing places were extremely limited. It is of interest to note that the move of this brigade was not detected by the enemy airmen, though the area was under continual observation."

Now it is clear that in war, the situation will rarely be such that we can allow an Infantry Brigade three hours to pass a point. During manœuvres, many fields are out of bounds, property has to be respected, hedges and fences cannot be cut and troops are forced to use only the existing roads and tracks. In war, steps would be taken to ensure that the reserve troops were sent up rapidly into line and yet remained undetected. Taking the situation of the 1st Division on the night preceding the operations just described, where such an advance is contemplated for the next day, it is certain that the C.R.E. would arrange for the marking and preparation of numerous tracks to the front, bridging, cutting, filling-in, etc., where necessary. With little chance of daylight reconnaissance, during the hours of one night, Field Company officers would be required to choose the line the new tracks were to take and carry out all necessary work. At dawn they would be required to follow up the advance and carry forward the tracks at the pace of the advance so that, at any time, reserves could be sent up without delay, concealed from air observation. It is in connection with this type of task that one wonders whether R.E. officers possess all obtainable knowledge regarding the concealment of communications from the air.

There is little doubt that the concealment of moving troops is becoming an art with which all officers—certainly R.E. officers—should be familiar. There are many factors affecting this question of concealment.

The first, and most obvious method of obtaining concealment from the air, is by the use of darkness. This method has its limitations. Darkness invariably slows up movement and can lead to confusion and loss of direction. Constant night work wears out troops and may result in loss of efficiency. At certain times of the

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year, in many latitudes, the hours of darkness are very short. Furthermore, airmen claim to-day, that, with the latest patterns of flares, great tracts of country can be lit up for considerable periods, showing up objects on the ground quite clearly. While darkness will always be regarded as the principal method of obtaining concealment, and will be made use of whenever possible, occasions will constantly arise (as with 1st Division manœuvres), when it is necessary to move troops in forward areas, by day.

In contemplating movement by day, the most important factor is the nature of the country. If we are operating on a prairie or a desert, it is probably almost useless to hope for concealed movement of troops by day. If we are fighting in close English country, as the 1924 manœuvres have shown, it is possible to move a brigade of Infantry without detection. The nature of cover to be found in the theatre of war will govern very largely whether there is to be day movement or night movement of the army. Next in importance to the nature of the country is the seasonal factor. In most possible theatres of war there are seasons in which, according as the vegetation is in leaf or not, the question of concealment from the air becomes easy or difficult. The factor of season should always be considered before making plans for concealment. Hand in hand with the consideration of season goes that of weather. It is true that there are now few days in the year in Europe on which aeroplanes cannot fly, yet there are a great many days in the year in which aeroplanes can see little. Prior to the great German offensive in March, 1918, there was a long period of dull weather which assisted materially in hiding the German movements. Aeroplanes flying low, under clouds, are not only more exposed to fire, but have a more limited and fleeting view of objects on the ground. Statistics, week by week, of weather in the theatre of war, will become a necessary addition to the original intelligence with which the Army embarks on a campaign.

The art of concealing moving troops is in its absolute infancy. There are a hundred and one facts yet to be determined. Let us examine some of the questions we should like to have answered in connection with the factors already mentioned. For instance, in movement by night, how do troops best remain concealed if lit up by aeroplane flares? Is it best to lie down or to remain standing still, or can they keep moving? On what surfaces should tracks be sited in order to show up troops least under flares? What coverings to hats, transport, etc., show up least under flares? Possibly those different in colour to those least visible in sunlight. In movement by day, are troops less visible at dawn and dusk and if so, why, and for how long a period after sunrise and before sunset? In operations on Salisbury Plain this year the writer noticed that after a night of heavy dew, at sunrise, the tracks of even individual

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men were distinctly visible *in grass* to an airman at 2,000 to 3,000 ft. Is this the case on all surfaces and, if not, what surfaces should be selected for tracks? Are troops equally visible by day on all surfaces? No! the difference in appearance of objects on tarmac and macadam surfaces, for instance, is remarkable. Which then are the preferable surfaces for day tracks? To what extent can shadow be utilized to hide movement? Troops under the dark shadow of woods and buildings are absolutely invisible from the air. Does this apply to a lesser extent to the lighter shadows cast by hills in the early morning and late evening? Where cross-country tracks cross water they are particularly liable to detection. Have we considered special arrangements such as the throwing of the bridges at the time of use only, or the selection of bridging sites likely to be (at any rate on one bank), in shadow at the contemplated time of crossing? Have we considered the effect of speed upon concealment? Are slow moving infantry more or less visible than fast-moving cavalry and tanks? Is the mechanical army of the future going to be easier to conceal on the move than the slower one of to-day? Is dust very visible from the air? If so, what are the best surfaces to counteract this? If the enemy knows where to look for your moving columns, his task is easier—but how much easier? Is this point vital or not? What is the effect of his height on the enemy airman's ability to see troops? Does it make a decisive difference keeping him at 20,000, 10,000 or even 5,000 ft. up?

What real difference do weather, clouds and the leaf on the trees make to the power of observation of the airman? Such, then, are some of the questions to which every officer in the Army should know the answer, just as he knows the range of a rifle or a field-gun.

How are we to set about determining the answer to these questions?

Were there an Army School of Intelligence, these matters would, no doubt, be tackled systematically and the lessons proclaimed to all. As it is, there are two Schools where the problems under discussion can be studied by R.E. officers, though it is not the duty of those Schools to specialize on this subject. These are the R.A.F. School of Army Co-operation at Old Sarum, and the R.A.F. School for Interpretation of Aeroplane Photography at Farnborough. Now that Army Orders provide that every officer shall fly, if there is need for him to do so, it is to be hoped that as many R.E. officers as possible will be sent to these schools to fly and to answer the questions that affect their work.

In war, Commanders of Formations will certainly rely on their Field Companies to find *concealed* forward communications for the movement of reserves. A reserve thrown into battle is absolutely wasted if its arrival has been previously detected. On Field Company officers will rest, therefore, a big responsibility. Are we equipped to take this on?

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# *MODERN ROAD CONSTRUCTION AND IMPROVEMENT ON THE NORTH-WEST FRONTIER OF INDIA.**

*By* MAJOR P. W. L. BROKE-SMITH, D.S.O., O.B.E., R.E.

## GENERAL REMARKS.

ROAD construction and improvement on the N.W. Frontier of India constitutes an important and interesting branch of the practical engineering work of the R.E. officer in India.

In the N.W. Frontier Province and Baluchistan, which are the N.W. Frontier provinces, all building and road work, both civil and military, is carried out by the Military Engineer Services.

Engineering work on the N.W. Frontier has a fascination of its own, and affords great opportunities to the active and keen R.E. officer for the exercise of responsibility and resourcefulness. Invaluable experience and training for war are afforded, in tackling engineering problems under limitations imposed by time and varying climatic conditions, in handling indigenous, imported, or military labour, in the utilization of locally available or the most suitable imported materials, and in transportation, often under active service conditions and frequently under conditions closely akin thereto.

The road constructional work now normally carried out in peace time by the R.E. officer in other parts of the Indian Empire is as a rule comparatively limited in its scope, and it is on the N.W. Frontier that the greatest experience is to be had in this class of work, for military or quasi-military purposes. In addition to the actual road building, the work of the Frontier engineer, particularly in connection or in conjunction with new roads in border territory, includes the construction of perimeter hutted camps, fortified posts, and blockhouses along the roads, for the accommodation of the regular troops, tribal or semi-tribal Militia and Scouts, tribal Levies, Frontier Constabulary, and Police, which control and police the border country.

Prior to the introduction of mechanical transport into the Army in India in 1915, the metalled roads maintained on the N.W. Frontier, and a number of " fair weather " partially-metalled or unmetalled roads which had been constructed for cart traffic and were on the

* Including the substance of a lecture delivered at the School of Military Engineering, Chatham, on 21st February, 1924.

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whole excellent for their purpose, were unsuitable for heavy mechanical transport traffic, although they could take occasional motor cars and the ubiquitous Ford van. Since 1916, the improvement of the existing metalled roads, and the metalling and improvement of important unmetalled roads, together with the construction of new roads in extension of the existing system, for strategical and administrative purposes, has been progressively undertaken in the N.W. Frontier Province. In Baluchistan but little has been done.

A particular object which has latterly been developed is to facilitate the control and administration of the border territory by the improvement and extension of the lateral communications parallel to the frontier, with fortified posts at intervals, in addition to the frontal roads running across the border up the principal pass routes. This phase of the work is exemplified by the recently built Central Waziristan road between the Derajât and the Tochi valley, and its continuation to the Kurram valley (Idak–Thall road), also by the Derajât Cis-Border road between Daraban and Ghazni Khel.

The principal road communications of the N.W. Frontier are shown on the appended map.

## M.T. ROADS BUILT AND IMPROVED SINCE 1916.

The principal work done in improving the Frontier road system for mechanical transport purposes, including the work in hand in 1914, comprises :—

*Frontal Roads Improved or Constructed.*

| | | |
|---|---|---|
| (i) | Malakand road (Nowshera–Dargai–Chakdara) | Improvements and bridging. |
| (ii) | Khyber road (Peshawar–Jamrud–Landikotal–Landi Khana) | Improvements and bridging and construction. |

[Double road through the Khyber pass beyond Jamrud. Includes construction of new sections S. road in replacement of old *nala* bed track.]

| | | |
|---|---|---|
| (iii) | Kurram road (Kohat–Thall–Parachinar) | Improvements and bridging. |
| (iv) | Tochi road (section Bannu–Miranshah) | Improvements and bridging. |

[Includes new length of road through Shinkai section between Bannu and Idak.]

| | | |
|---|---|---|
| (v) | Bolan road (section Sibi–Rindli–Kolepur) | Improvements and bridging and construction. |

[New road constructed Sibi–Rindli at lower end of Bolan Pass. Road Rindli–Kolepur re-opened and improved as an unmetalled, partially bridged road.]

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# · PRINCIPAL ROAD COMMUNICATIONS ON THE N.W. FRONTIER OF INDIA ·

SCALE: 32 MILES TO 1 INCH.

Miles 10 6 0 10 20 30 40 50 60 70 80 90 100 Miles.

REFERENCES.

- Metalled Roads
- " " under Const[n]
- Partially Metalled Roads.
- Unmetalled Cart Roads.
- Pack Roads.
- Broad Gauge Railways.
- Narrow. " "
- Boar Bridge. B.B.
- Ferry. F.

AFGHANISTAN

KABUL
KANDAHAR
Ghazni
Kabul R.
Peiwar P.
Parachinar
Chaman
Bogra P.
Khojak
QUETTA CHAMAN RD.
Kila Abdullah
Ghwaza
Gulistan
Spinatizha
Pishin
Khanozai
Karu
Khanai Kach
Ziarat.
Hindubagh
Kila Saifullah
Zhob R.
Surkai Zangal
Sharan
LORALAI
Mekhtar
Kingri
Smallan
HARNAI
Harnai
Kolpur
QUETTA NAUSHKI RD.
Nushki
From Dalbandin
Riddli
SIBI
KALAT
To Sukkur and Karachi
BALUCHISTAN
Kurram R.
Thall
KOHAT PASS RD.
KOHAT
KURRAM ROAD
Spinwam
Dardoni
Shirani
Tal
Datta Khel
Razmak Narai
Razani
RAZMAK
Makin
Dwa Toi
Piazha
Saraogha
Idak
Tochi R.
BANNU FRONTIER RD.
Wana
Sarwakai
Tanai
Khajuri Kach
Gomal R.
Gomal
Koikal
Jandola
Khirgi
Murtaza
GOMAL PASS RD.
Gomal
Kaur
Boose
Ro.
Sanik
Ghazni Khel
Kalabagh F.
Mari Indus
Daud Khel
Kundian
To Lahore
NORTH WEST FRONTIER PROVINCE
CHITRAL
Kila Drosh
Dir
Panjkora R.
Swat R.
Sado
Chakdara
Malakand
Dargai
MALAKAND
Abazai
Kabul R.
Michni
Mardan
Swabi
Loe Shilman
Kam Shilman
Landi Khana
Landi Kotal
Khyber P.
Ali Masjid
Jamrud
PESHAWAR
Newshera
Cherat
Attock
Campbellpore
Hassan Abdal
HAZARA TRUNK ROAD
ABBOTTABAD
Havelian
Murree
Sarai Kala
Goira
RAWALPINDI
To Srinagar.
To Jhelum and Lahore.
R. Indus
KASHMIR
Basal
Khushalgarh
Gumbat
Thall
Darabanda
DERA ISMAIL KHAN
Mir Ali Khel
Mani Kwa
Ga Meenal Kot
Dhana Sar
Kabib
FORT SANDEMAN
Murgha
Zhob R.
SANDEMAN RD.
Sumner P. Winter.
Darya Khan.
PUNJAB
Indus R.
From Sukkur and Karachi
DERA GHAZI KHAN
Fort Munro
Sanzal Chak
MULTAN
To Lahore.

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*Frontal Roads Partially Improved or Constructed.*

(vi) Tochi road (section Miranshah–Datta Khel) — Improvements.

[Work stopped during Afghan War, 1919, and not resumed owing to subsequent relatively greater importance of other roads.]

(vii) Gomal road (Kaur–Murtaza–Khajuri Kach) — Improvements and bridging and construction.

*Lateral Roads Improved or Constructed.*

(viii) Peshawar–Shabkadr–Abazai road — Improvements and strengthening boat bridges.

(ix) Peshawar–Michni–Shabkadr road — Improvements and bridging.

(x) Landikotal–Kam Shilman–Loe Shilman road — Improvements and construction.

[New road Kam Shilman–Loe Shilman. Work closed down after Afghan War, 1919, nearly completed.]

(xi) Central Waziristan road (Kaur–Khirgi–Jandola–Sararogha–Razmak–Isha) — Construction.

[Bridging across main *nalas*, some metalling, etc., remain between Jandola and Razmak, to be done as and when finances permit.]

(xii) Jandola–Sarwakai road — Construction.

(xiii) Dera Ismail Khan–Tank–Kaur road — Improvements and bridging.

[Includes new section 4 m. long between D.I. Khan and Tank.]

*Lateral Roads Partially Improved or Constructed.*

(xiv) Idak–Spinwam–Thall road — Improvements and construction.
In hand.

(xv) Derajât Cis-Border road (Daraban–Kaur and Tank–Ghazni Khel) — Construction.

[Along administrative border between administered territory and the more independent tribal area.]
In hand.

*Miscellaneous.*

(xvi) Various miscellaneous improvements, including construction or reconstruction of a few bridges, have been carried out on certain other roads, which have not been systematically improved.

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In Baluchistan, an unmetalled cart road has been built between Surkai Zangal and Kila Saïfulla, to connect Loralai with the Zhob valley, and a pack road has been made over the Bogra Pass.

The principal improvements required to the old roads include, to the extent necessary on each road :—

(i) Metalling where unmetalled, thickening metalling (including providing proper soling foundations where non-existent or insufficient), and widening metalling, according to the standard required.

(ii) Widening roadway where too narrow, particularly at the sharp corners which are frequent on hill roads, such as the greater part of these roads are.

(iii) Improving blind or too sharply curved and graded corners in hill sections.

(iv) Provision of cross-banking or super-elevation on sharp curves, particularly in hill sections.

(v) Bridging over unbridged rivers or *nala* crossings, except over minor *nalas*, where causeways may be provided or retained if suitable for the standard, and reconstruction and strengthening of old bridges.

(vi) Improvement of cross drainage, and reconstruction of weak culverts, including widening roadway over culverts where necessary. [The necessity for adequate cross-drainage on hill roads in a country of torrential and spasmodic rainfall is generally learnt by bitter experience.]

(vii) Provision of additional retaining walls, and reconstruction of weak retaining walls.

(viii) Realignment in cases in which the old alignment traverses faulty terrain (*e.g.*, shale or clay cliffs), where the road is liable to be constantly blocked by débris, particularly after rain, or gradually disappears down the hill side.

In all, since 1916, some 370 miles of road have been improved to various standards, including a good deal of bridging, and about 200 miles of new road have been built. With the completion of the roads now in hand, these totals will be increased to approximately 400 and 260 miles.

The bridging work done includes 29 girder bridges averaging 300 ft. in length (usual length of spans, about 100 ft.), besides many arched bridges (principally with stone arches, but including brick and a few concrete arches), and bridges of reinforced concrete decking on steel joists.

The expenditure incurred on the above-mentioned projects works out at roughly, 30,000 rupees, or £2,000, per mile, for improvements, and 167,000 rupees, or, say, £11,000, per mile, for new construction, including bridging, on the average.

The costs, which have risen considerably since 1917, of course vary with the locality, the nature of the country, and the conditions

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of work, and are considerably higher in trans-border than in cis-border areas. The recently current rates for new roads in Waziristan, for purposes of approximate estimating, are Class I, Rs. 1.9 lakhs (or £13,000) per mile, Class II, Rs. 1.6 lakhs (or £11,000), Class III, Rs. 1.3 lakhs (or £9,000); major bridges of girder type cost approximately Rs. 1,000 (or £67) per foot run.

## Outstanding Items.

A good deal of further work remains to be done if the N.W. Frontier road system is to be made reasonably complete in through communications fit for mechanical transport. This is particularly the case in Baluchistan and the N.W. Frontier Province, the bulk of the roads in Baluchistan being below mechanical transport standards, and there being no direct communication between Baluchistan and the N.W. Frontier Province either by rail or road.

The resuscitation and improvement of the old Golra–Khushalgarh and Gombat–Attock roads would also greatly improve the rearward communications to the central portion of the N.W. Frontier Province and the lateral communications between the Kohat district and the north: the Kohat–Peshawar road passes through practically independent territory and is therefore liable to interruption, although, as a result of the settlement with the local tribesmen after the murder of Mrs. Ellis at Kohat in 1923, the conditions through the Kohat pass should be improved.

## Railways.

In deciding the standards for individual roads, upon the basis of traffic requirements (tempered by financial considerations), regard is, of course, paid to the railway system, with which the road system should be co-ordinated.

With reference to the railway system, roads may be classified as under:—

(i) Roads in advance of railheads, and roads radiating out from railways.

(ii) Roads parallel or approximately parallel to neighbouring railway lines.

The provision or improvement of a railway line does not necessarily do away with the necessity for the provision or upkeep of a road parallel to it, although, according to the standard of the line and its capacity for traffic, the standard necessary for the parallel road may need modification. Thus the completion of the Khyber railway will do away with the normal necessity for the second motor road, which, however, should remain useful for animal transport and for mechanical transport in emergencies.

Consideration of the railway system of the N.W. Frontier of India

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is beyond the scope of this paper. The existing lines are shown on the appended road map. Improvements (*e.g.*, conversion from narrow to broad gauge and doubling single lines) and extensions are carried out from time to time, as necessity dictates and financial considerations permit. Amongst the improvements and extensions carried out in recent years may be noted the conversion to broad-gauge of the Nowshera–Dargai line, the construction of the Khyber extension from Jamrud to Landi Khana, which is under completion, the construction of the narrow-gauge line from Kalabagh to Khirgi in S. Waziristan and Bannu in N. Waziristan, and the extension of the Quetta–Nushki railway to the Persian border.

Future items that suggest themselves are :—

(i) A railway bridge across the R. Indus gorge between Mari Indus and Kalabagh, to replace the present steam-ferry connection.

[A bridge of any sort over the R. Indus crossing between Darya Khan and Dera Ismail Khan is out of the question : the river course varies from year to year over a ten-mile width, and in recent years the continued existence of Dera Ismail Khan has become seriously imperilled.]

(ii) Conversion to broad gauge of existing narrow-gauge lines, according to requirements.

(iii) Permanent line from Tank to Dera Ismail Khan.

(iv) Direct railway communication between Baluchistan and the N.W. Frontier Province *via* Fort Sandeman.

## ROAD STANDARDS AND SPECIFICATIONS.

The normal road standards now in use are described below. These are the usual Military standards ; the standards for Civil Frontier roads are generally similar.

| Metalled or Un-metalled. | Class. | Standard for Traffic. | Description. |
|---|---|---|---|
| M. | I | Suitable for "Continuous" M.T. traffic | 24′ roadway, metalled 16′ wide, fully bridged (*i.e.*, bridged except where traffic would not be impeded over causeways). [In special cases, *e.g.*, in cantonments, widths may be greater.] |
| M. | II | Suitable for "Intermittent" M.T. traffic | 20′ roadway metalled 12′ wide, partially bridged (*i.e.*, bridged across perennial streams, and where traffic would be impeded across causeways for over 24 hours—causeways otherwise provided in lieu of bridges where practicable and cheaper). |

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| Metalled or Unmetalled. | Class. | Standard for Traffic. | Description. |
|---|---|---|---|
| M. | III | Suitable for "Occasional" M.T. traffic | 18′ roadway, metalled 9′ wide, unbridged except across perennial streams (causeways provided elsewhere in lieu of bridges, where practicable and cheaper). |
| U. | IV | Suitable for carts (and in certain cases for occasional light M.T. traffic, principally in dry weather only) | 12′ roadway, unmetalled, unbridged except across perennial streams. (Surface may be shingled where soft.) |
| U. | V | Suitable for camel traffic | 10′ roadway, unmetalled and unbridged (practically exclusively hill roads). |
| U. | VI | Suitable for pack mule traffic | 8′ roadway, unmetalled and unbridged (practically exclusively hill roads). |

NOTE.—These standards may be varied to suit particular local conditions. Bridging to be individually decided for each road. Essential culverts and small bridges (*e.g.*, for cross-drainage and where necessitated by the alignment) to be given in all cases.

In connection with the improvement and construction of roads for mechanical transport we are, of course, only concerned with the metalled standards, *i.e.*, Classes I to III. Unmetalled roads are now not usually constructed to any extent, except in certain areas where mechanical transport is not used (*e.g.*, Chitral), and as field service roads. In special cases, the initial provision of an unmetalled cart road (Class IV), fit in fine weather for occasional light mechanical transport, to be improved later, may be considered where it can be made to suffice and a metalled standard absolutely cannot be afforded: this is a cheap and nasty makeshift. In some localities, as in parts of Baluchistan, where the natural soil is of a hard gravelly nature, well-made unmetalled roads will take a surprising amount of light mechanical transport traffic, if well looked after.

It is laid down that the alignment, etc., of a Class II or III road shall be such that the road can be converted to a higher standard later if required: the alignment specified for a Class IV road is the same as for metalled roads, with the same object. This principle of convertibility is always valuable, and it is of particular importance in the case of these roads on account of the fact that for reasons of expense many of the roads have to be made to the cheapest possible practicable specification in the first instance.

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The salient points of the present specifications for metalled roads are as follows :—

*Gradients.*—(i) Ruling—1 in 20. In long stretches of ruling gradient, flats 100'–200' long to be given about every half mile.

(ii) Maximum—1 in 13, over distances not exceeding 300'. On sharp curves, gradient to be *nil* or very slight.

(iii) Maximum rise per mile—240'.

*Radius of Curves.*—Centre of roadway.

(i) Normal minimum—60'.

(ii) Minimum at hill zigzags—35'.

*Super-elevation on Curves.*—(i) Maximum, for radius 35'—1 in 7.

(ii) For radius 50'—1 in 10 ; 100'—1 in 20.

Inversely proportional to radius of curve.

*Width of Roadway.*—At formation level, excluding side drains and parapet walls.

(i) Normal width—Class I 24', II 20', III 18'.

(ii) Increased 2' to 4' on embankments and at sharp corners. Inner side at blind corners in hill sections cut down to give drivers clear view round corner.

(iii) Reduced 4' to 2' in straight hard rock cuttings.

*Soling.*—Except where unnecessary on rock or hard conglomerate.

(i) Normal width—1' wider than metalling. Full roadway width on very soft formations.

(ii) Normal thickness—6" to 9". Increased where necessary on very soft formations.

*Metalling.*—(i) Normal width—Class I 16', II 12', III 9'. Widened 3' to 4' on sharp curves. Full width over bridges and culverts.

(ii) Normal thickness before consolidation—Class I 9", II 6", III $4\frac{1}{2}$". Ditto after consolidation—Class I 6", II 4", III 3". Layers $4\frac{1}{2}$" to 6" thick.

*Camber.*—Crown slopes, curved off.

(i) Normal—1 in 40.

(ii) On curves—super-elevation cross-slope.

*Clear Width of Culverts.* (Not over 12' between abutments).

Clear roadway width. Humps in road to be avoided.

*Clear Width of Scuppers.* (Paved dips not over 20' span across.)

Clear roadway width.

Scuppers used in lower standards in preference to culverts, where practicable and cheaper. Sharp dips in road to be avoided.

*Clear Width of Bridges.*—(i) Normal—Classes I and II 18', III 10'. To facilitate subsequent improvement, arch bridges on Class III roads may be 18' wide, and piers and abutments of other bridges may be as for 18' width.

(ii) Small bridges on sharp curves may be up to 4' wider.

*Width of Causeways and Overflow Bridges.*—Classes I and II—18', III—12'.

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*Tunnels.*—(i) Normal clear width—Classes I and II 18′, III 12′.
(ii) Normal headway—
13′ minimum over centre of roadway.
8′ minimum over sides of roadway.

*Sidings.*—Normal size 66′×16′ maximum width; outside edge on arc of 39′ radius. Normally to be provided at watering places, at the tops of long inclines, and at each end of one-way traffic bridges, as ordered. On specially important M.T. roads, may be provided in hill sections at regular intervals (*e.g.*, every mile), alongside level stretches as far as possible.

*Parking Places.*—At termini and stages, as required.

*Road Signs.*—Mile and furlong stones, direction posts and place-name signs, warning signs and notices, road-name signs. For warning signs symbols similar to those laid down by the British Ministry of Transport are standardized.

*Strength of Bridges and Culverts.*—Calculated as for 12-ton steam-roller with 25% impact. Will take any train of loads in which no axle load exceeds 12 tons and no distributed or caterpillar load exceeds 18 tons, under due precautions as to intervals, speed, load on centre of road, and no other load alongside, in the case of the heavier loads.

These specifications have not been followed uniformly, owing to alterations and improvements made as experience has been gained and the requirements have developed.

The criterion adopted for the specifications is suitability for military mechanical transport lorry traffic at minimum cost. Roads built in accordance with them will take all the other classes of Indian military traffic, and equivalent civil traffic. The various standards are devised to suit the volumes of traffic which may be expected on such roads. Bridges constructed according to these specifications will take vehicles up to 10-ton tractors and 18-ton whippet tanks, with due precautions as to speed and intervals.

For financial and practical reasons, a better surface than water-bound macadam (on suitable soling) is not at present generally specified for Indian roads, except in certain of the most civilized cities and towns, and the Frontier metalled roads are so surfaced, a very good grade of limestone being generally available. There can be no doubt, however, that in the future more modern methods, such as the use of tar-spraying, tar macadam, or cement concrete, must be gradually introduced on the principal roads, if and when financial exigencies admit of the necessary comparatively heavy initial outlay. The tar treatment of roads is already in use in various large cities and cantonments in India, with varying degrees of success, experience in devising specifications suitable to the climatic conditions and to the available materials being progressively gained. Non-slippery surfaces, which are desirable in any case, are particularly important in the case of hill roads and of roads carrying a considerable proportion of animal transport; this factor has to be

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taken into consideration in the specifications for surfacing, in addition to providing for the necessary firmness and durability under extremes of heat and cold.

Another direction in which the present standard of Indian roads generally is susceptible of improvement is in the abolition of the present usual limitation of the metalling to a central strip, the sides or berms of the roadway being unmetalled or merely gravelled and rolled. To effect this improvement to any appreciable extent, having regard to the large mileage involved, would, of course, involve an impracticable financial outlay. So, for the present at any rate, the disadvantages of dust and mud and limitation of wheeled traffic capacity, particularly in wet weather, must be put up with. It is, however, possible to mitigate the disadvantages by gravelling and rolling the berms, and by tar-spraying, as done on earthen roads in America. The disadvantages are, of course, less on minor roads, and also on hill roads, which the Indian Frontier roads largely are. In hill roads on the N.W. Frontier the berms, except in embankments, are frequently of a durable gravelly or rocky nature, and are usable by passing traffic more often than not, owing to the spasmodic and comparatively small rainfall.

A third special feature of the Indian Frontier roads, which, as mentioned above, are largely hill roads, is the mountain *nala* crossings which abound. These *nalas* usually have boulder and gravel beds, and are generally dry, or practically so, except for a small trickling stream, under which conditions wheeled traffic can cross them, the surface being suitably smoothed, or a paved causeway being provided in lieu of bridging, to save expense. But the intermittent spates to which these *nalas* are liable at uncertain intervals, and which are generally worst during the summer months between July and October, are liable to completely breach the roads for all traffic at all except minor *nala* crossings, unless they are bridged. Although a spate, which may be 6 ft. deep or more, may only last for a few hours, the remaking or clearing of the roadway for wheeled traffic is often a matter of days, particularly in remote places where labour is not rapidly obtainable ; moreover even when an unbridged crossing has been so reopened, as likely as not, particularly during the spate season, it will be breached again the next day.

## PHOTOGRAPHS.

A selection of photographs* is appended, to convey a general idea of the work and the surroundings. These photographs principally illustrate the Central Waziristan road, which has recently been completed in first essentials, and furnishes a notable example

* Included in a series of slides shown at the lecture at the S.M.E., on 21st February, 1924.

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of modern Frontier road work. The final sections of this road, *viz.*, Isha–Razmak from the Tochi end, and Sararogha–Razmak from the south, 41 and 24½ miles long, were built in 14 and 8 months respectively, a memorable achievement. (The latter was completed in first essentials only.)

The following notes deal with points of practical interest relevant to these photographs :—

No. 1. *Ali Masjid Gorge, Khyber Road*, 1920.—Showing the double road. Improved north road on the left, showing banking and widening at corners. New section of south road on the right. The bridging was hastily completed during the Afghan war in 1919 ; the constricted bridge approaches were subsequently improved.

No. 2. *Boat Bridge at Adozai, Peshawar–Shabkadr Road*, 1920.—An example of the old boat bridges which remain in some places. On important roads they are replaced by permanent structures, when funds permit. Note the special system of removable and adjustable trestles, devised to carry the superstructure in the cold weather low-water season, when this channel nearly dries up and the boats are aground.

No. 3. *Main Stream Kabul River Bridge at Michni, Peshawar–Michni Road*, 1920.—Six 100-ft. girder spans, on brick masonry piers and abutments, on well foundations with concrete core. Roadway carried on reinforced concrete decking, supported by cross-joists carried on the top booms of the girders. One of a pair of bridges, the other being of two 110-ft. and one 140-ft. girder spans, constructed across the two branches of the Kabul river at Michni in 1918–19. These bridges were built in conjunction with the Bridge Engineer N.W. Railway, under a system by which the Bridge Engineer undertook the provision and erection of all large bridge steelwork, using old railway girders made available by the remodelling of old railway bridges, with resultant efficiency and economy. In this case the Bridge Engineer was also responsible for the sinking of the well foundations in deep water by a specially devised method, the bridges being completed, except for decking, in five months. Under the system now in force for Frontier girder bridges, the Military Engineer Services are responsible for all erection work at site, the Bridge Engineer supplying the steelwork, remodelling the girders as necessary, and advising technically. The system of bridgehead protection by diagonally opposite block-houses may be noted. This type of bridge (steel girders on masonry piers, usually of stone), has hitherto been the normal type for all Frontier road major bridges in recent years, including the more common bridges across *nalas* in the hills, which are practically dry except when spates occur. The alternative use of pile bridges for the latter crossings, to reduce expense, has recently been under consideration. Suspension bridges have hitherto been but little used, but there should be a future for them on the Frontier hill roads if the security objection to this type in trans-border districts can be overcome. This latter factor, *viz.*, security of road structures against wilful damage by malcontent tribesmen or mischievous travellers, has to be reckoned with, and the simplest and sturdiest forms of structures must, therefore, preferably be used in

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all cases. For the same reason, road signs (*e.g.*, mileage, danger signs, etc.), are frequently painted on large rocks.

No. 4. *Khirgi Camp, Kaur–Jandola Road, September*, 1922.—A typical view, showing a military camp and the entrance of a Frontier road into the hills of tribal territory. The kink in the road is due to the diversion of the road around an aeroplane landing-ground, which was selected after the road had been constructed. This is an example of the necessity for co-ordination and the exercise, by the roadmaker, of a high degree of imagination to provide for all possible contingencies in aligning a road.

No. 5. *View down Khirgi–Jandola Road, September*, 1922.—Showing the Lower Zam or Kiriwam Bridge and a typical stretch of trans-border country. These roads frequently have to be opened for traffic before completion, and the engineer has to proceed (with diversions where possible) whilst traffic is passing. This bridge had to be temporarily floored with sleepers, pending completion with steel troughing when the latter arrived from England. [Note the road post (blockhouse) on the hill on the left.]

No. 6. *Takki Zam Nala Bed Section, Kotkai–Sararogha Road*, 1922.—An example of a case in which the only practicable alignment through this difficult country lies alongside the *nala* for about half a mile, at the foot of precipitous high cliffs, the alternative being a more expensive detour, involving an increase in distance (an important matter from the staging convoy point of view), steep winding gradients, traffic protection difficulties, and greater expense. A similar case, near Kotkai, in which the conditions were worse owing to the sharply curving conformation of the *nala*, was ultimately solved by the provision of a tunnel through a hard conglomerate salient. In this latter case, the "engineering" alignment traversed a plateau, through a graveyard. The Mahsuds, however, would not agree to the road being built on this alignment, even on payment of the comparatively heavy compensation which is customary whenever a road alignment necessitates acquisition of cultivatable land, diversion of irrigation channels, displacement of graves, etc. So a deviation along the bank of a side *nala*, followed by a steep climb over a hill, joining the "engineering" or "true" alignment beyond, had to be adopted at much greater expense; the first portion of this deviation has recently been made permanent with the aid of the tunnel.

This latter furnishes an example of one of the special features of engineering work in trans-border areas or tribal territory, *viz.*, the subordination of engineering desiderata to political exigencies, when they conflict. The Frontier engineer must work in the closest co-operation with the political officer.

It is also a good example of the use of tunnels, which are not common on these roads.

No. 7. *Ahnai Tangi, Kotkai–Sararogha Road*, 1922.—An example of a Frontier gorge, where the torrent has forced a narrow opening through a fault in a solid rock formation. The floods through such gorges rise to 20 ft. or more. They come down very suddenly, and last only a few hours. In the absence of a made road, the *nalas* form

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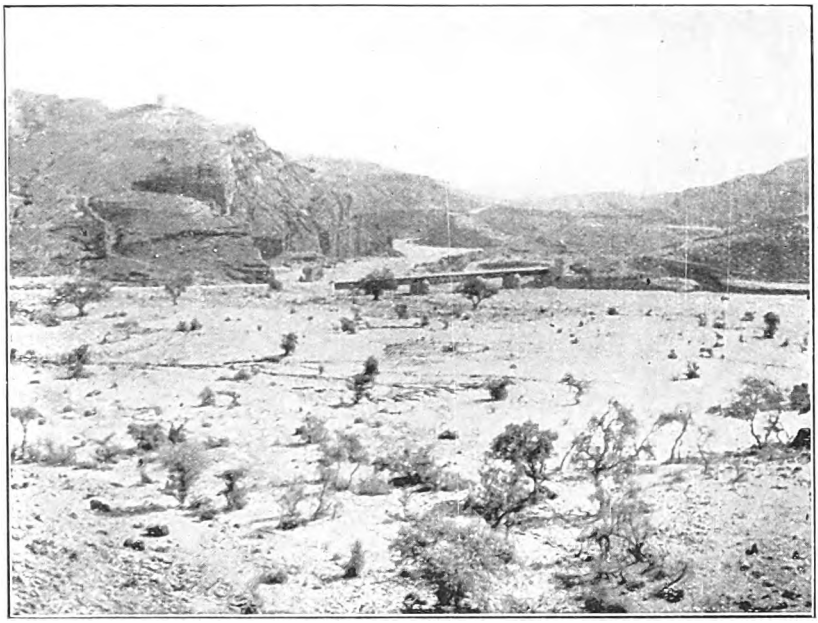

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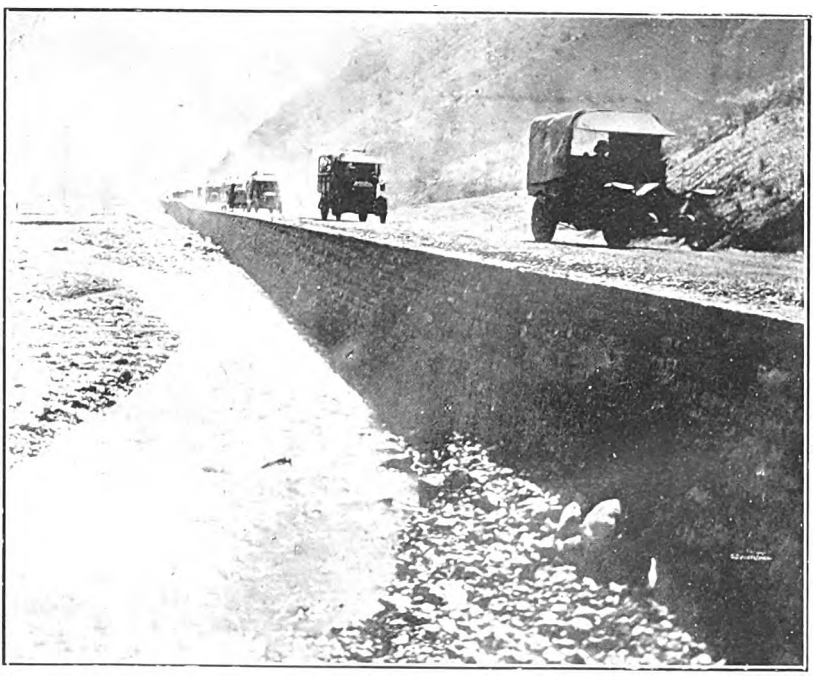

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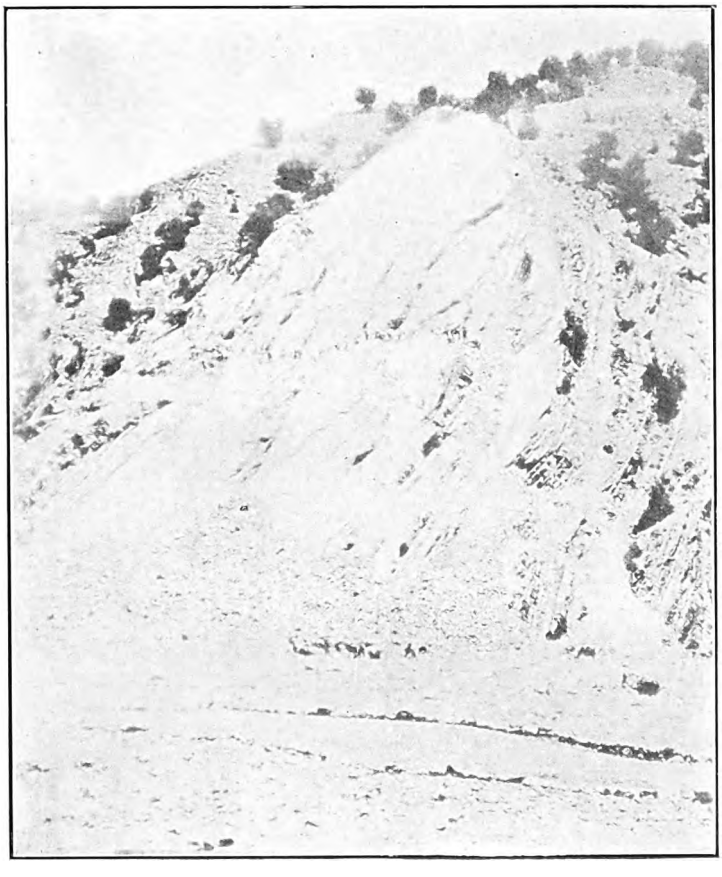

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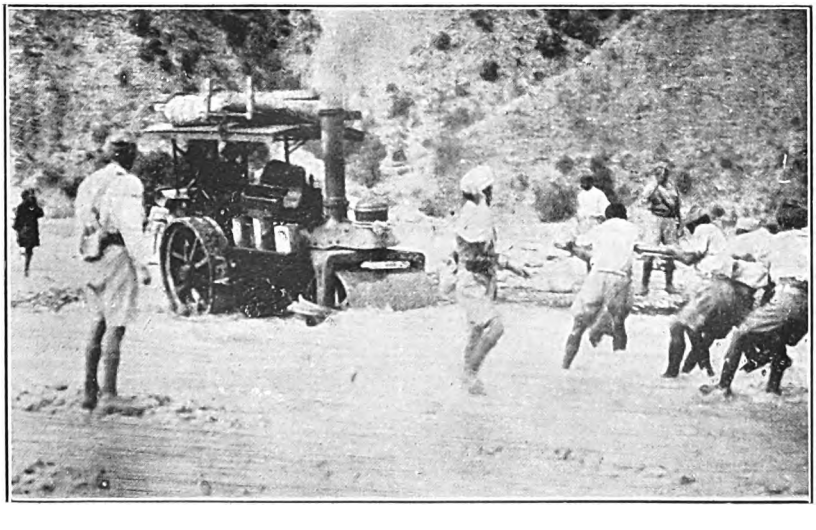

Photo No. 10.

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Photo No. 11.

Photo No. 12.

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the usual highways in the hills. Troops and transport have been drowned in this gorge, before the road was made.

No. 8. *View down Sararogha–Razmak Road below Piazha, May*, 1923.—Showing road about two months after work commenced. (Note one of the camel convoys which transport supplies in the absence of a made road, and until the new road is fit for vehicular traffic.)

No. 9. *Rock-cutting near Aka Khel, Sararogha–Razmak Road, May*, 1923.—Showing Pioneers cutting out the road on a precipitous rock cliff. A great deal of the work on the final sections of the Central Waziristan road, between Sararogha and Isha, including all the difficult rock-cutting between Sararogha and Dwa Toi, was done by Sappers and Miners and Pioneers; it was evident that the road could not be completed in a reasonable time by the usual civil contract system alone.

No. 10. *Steam-roller en route across Takki Zam, Sararogha–Razmak Road, May*, 1923.—As soon as a section of new roadway is ready, steam-rollers are pushed forward in this manner; an easy forward section may often be ready for metalling before a difficult rearward section. The roller is being dragged by troops. Civilian labour, which has to be largely imported, will not come to or remain in a disturbed trans-border area in adequate quantities, particularly an area of hostilities such as Waziristan has been during the construction and improvement of roads therein, practically continuously since 1916.

No. 11. *Tal (Tochi) Causeway, Isha-Razmak Road*, 1923.—Showing the temporary causeway, constructed for use pending the building of a bridge, submerged and impassable for wheeled traffic. This illustrates the futility of causeways on main *nala* crossings, when permanent road communication is required. A girder bridge of six 110-ft. girder spans has now been completed here.

No. 12. *Razmak–Narai Ascent, Isha-Razmak Road, February*, 1923.—Showing military labour at work in the snow, clearing the road alignment. A fine road has been made up this difficult precipitous ascent, which is over 1,000 ft. high, from the Khaisora valley above Razani on to the Razmak plateau, on which Razmak, dominating the heart of Waziristan, is situated. The alignment winds up the hillside, with gentle gradients, wide corners, etc., according to the specifications, the rise being reduced to the maximum permissible rise of 240 ft. per mile. In contradistinction to the excessive heat of the summer months in the areas where the bulk of the road work is carried out in the N.W. Frontier Province, the winter at this high altitude (Razmak plateau is some 8,000 ft. above sea-level) is severe. When Razmak was occupied in the winter of 1922–23, a camel road was run up this Razmak–Narai ascent in the first instance, to permit of the maintenance of the troops at Razmak pending the completion of the mechanical transport road. The Isha–Razmak road was progressively opened to mechanical transport traffic by stages as soon as they were completed in first essentials, and the pack transport stages, in advance of the mechanical transport, were correspondingly reduced. Alternative camel tracks were also made over the passes between the Tochi and the Khaisora, for use pending the completion of the road for the full volume of M.T. traffic, and the abolition of pack transport on the line.

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## *THE SENIOR OFFICERS' SCHOOL.*

*By* MAJOR AND BREVET LIEUT.-COLONEL A. C. DOBSON, D.S.O., R.E.

THE objects of the Senior Officers' School are laid down in *K.R.*, 1923, paras. 815–816. They are :—

1. To disseminate and inculcate sound tactical principles as laid down in the official manuals, thereby ensuring uniformity of method in their application throughout the Army.

2. To give Senior Officers of all arms an opportunity of exchanging ideas as to the most approved and up-to-date methods in all matters connected with the training and administration of units.

3. To give higher tactical training to Senior Regimental Officers of all arms and assist them to train and administer a battalion or equivalent unit, according to the arm of the service to which they belong.

4. To report on officers as regards their ability to conduct the training and administration of a battalion or equivalent unit.

All combatant officers below the rank of substantive Lieut.-Colonel are required to undergo a course at the School before they can be considered for promotion to higher substantive rank.

Before an officer can undergo the course he must have :—

1. Reached the substantive rank of Major.

2. Served a continuous period of six months with his unit during two years immediately prior to his attendance at the School.

3. Been recommended for promotion in his annual confidential report.

Conditions 1 and 3 are invariably complied with, but circumstances may often, in the case of R.E. officers, prevent condition 2 being fulfilled, as many R.E. officers approaching their promotion to Lieut.-Colonel have been in civil employ and away from military duties for some considerable time when their turn to attend the S.O.S. Course comes round, and often cannot be spared from their jobs to do the qualifying six months with a unit of the Corps.

These notes have been compiled in the hope that they may be useful to such officers.

The School is situated at Sheerness in the old R.A. Barracks.

The telegraphic address is " Senos, Sheerness."

Telephone number : Sheerness 41 Military.

The Directing Staff consists of a Commandant, a Chief Instructor, a Cavalry Instructor, an Artillery Instructor, two Instructors in administrative duties (" A " and " Q "), three Infantry Instructors, and an Adjutant and Q.M.

The three Infantry Instructors also act as Leaders of the three

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"syndicates" (consisting of officers of all arms), into which each batch of students is organized.

ACCOMMODATION.—A single field officer's furnished quarter is allotted to each student; these are either converted barrack rooms or adapted married quarters.

The barrack rooms are delightful in summer and nearer the Mess than the married quarters. On the other hand they are not so cosy as the married quarters in winter, and are further away from the Lecture Hall and offices. Blankets, sheets, pillow-slips and towels should be taken.

There are two hotels in Sheerness where married officers can obtain accommodation for their wives and families, *viz.*:—

The "Royal Fountain" in Blue Town, and the "Royal" in Broadway.

Both are within a few minutes' walk of the School.

A list of furnished apartments can be obtained from the Adjutant on application. Houses are practically unobtainable.

To obtain the best value from the course, officers are strongly advised to live in the Mess; as it is after dinner when yarns are being told and "lies swapped" that the best opportunities arise of exchanging ideas in friendly discussion.

Motor cars or motor cycles are essential, as practically all tactical schemes are carried out on the mainland, a distance of over ten miles in each direction. Garage accommodation is provided at the school for forty cars at a rental of 10s. per month. This covers the use of water for washing cars, electric light, etc.

BOOKS.—It has been laid down by the C.I.G.S. that the type of war we have to train for is mobile warfare against an enemy equally as well armed as ourselves. The only books that officers are required to bring with them to the School are:—

*F.S. Regulations*, Vols. I and II.; *Infantry Training*, Vols. I and II; *Cavalry Training*, Vol. II (*War*); *Artillery Training*, Vol. III (*War*); *King's Regulations*; *Manual of Military Law.*

In addition to the foregoing the following manuals are useful and officers are recommended to obtain them and read them before joining:—

*Engineer Training; Machine-Gun Training; Tank Training; Educational Training; Training and Manœuvre Regulations; Manual of Movement: Manual of Map-Reading and Field Sketching: Manual of Smoke; Manual of Field Works* (*All Arms*).

The following two pamphlets, published by the G.S. War Office, are also useful:—

*Notes on Elementary Tactical Training; Section Leading in Attack and Defence.*

It will be seen from the foregoing list that only official books and

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regulations should be studied. Unofficial publications are viewed with disfavour, but the following two may be recommended :—

*Notes on Infantry Tactics and Training*, by the late Lieut.-General Sir G. M. Harper, K.C.B., D.S.O., and

*Military Organization and Administration*, by Major W. G. Lindsell, D.S.O., O.B.E., R.A. (Gale & Polden).

The latter contains in a handy form a vast amount of information which is scattered throughout a number of official publications and has the advantage (at present) of being right up to date.

The course lasts twelve weeks and consists of lectures both by the Staff and outside Lecturers, discussions, tactical schemes (both outdoor and indoor), and visits to outside units, *e.g.*, the Artillery School at Larkhill, the M.G. School at Netheravon, etc., etc.

In addition to the solution of tactical problems (which are carried out in small groups of three or four officers) students are also required to prepare two or three tactical schemes embodying simple problems suitable for setting to junior officers and to N.C.O.'s of their own arm. They are also required to write a Memorandum on training their own unit. These two latter are carried out individually and not by " groups."

Students are also invited to give a lecture on any subject of military interest, but unless the lecture is a really good one and the lecturer absolutely " question proof " this is better not attempted.

DRESS.—The following is the order of dress worn at the School :—

(*a*). *Morning Lectures.*—Service dress ; riding breeches. Belts need not be worn.

*Note.*—Belts will be worn by officers living out of barracks when proceeding to and from their residences.

(*b*). *Afternoon or Evening Lectures.*—Plain clothes, unless otherwise ordered.

(*c*). *Outdoor Work.*—Plain clothes, unless otherwise ordered.

(*d*). *Visits to Outside Units.*—Service dress; breeches and Sam Browne belt.

(*e*). *Mess.*—Mess Kit. Officers not in possession of Mess kit will wear evening dress coat. Dinner jacket may be worn on Saturdays. Supper on Sundays—any kit may be worn.

GAMES, LEAVE, ETC.—There are excellent tennis courts within a few minutes' walk of the School at Well Marsh, a racquet court exists in the Barracks ; it is at present used for badminton, but a proposal has been made to convert it to a " squash " court.

The Sheerness Golf Course (9 holes) is within two miles of the School. Officers can become full members for the period of the course on payment of a subscription of £1 11s. 6d., which is collected through the Mess bill.

Leave from the end of the week's studies until Monday morning, 11.30 a.m., may be taken without application.

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# *HISTORY OF THE 12th COMPANY ROYAL ENGINEERS.*

*(Continued.)*

*By* LIEUT. M. R. CALDWELL, R.E.

## CHAPTER IV.

*Mobilization.*—At 6.45 p.m. on August 4th, 1914, a telegram was received from "Commandeth, Dublin" ordering mobilization, whereupon everything became activity! All went smoothly and the Company was complete a day ahead of its schedule time, parading fully mobilized on August 11th, three additional officers and some 70 reservists having joined.

*Personnel.*—The strength of the Company was now 6 officers and 211 other ranks, the officers being Major A. F. Sargeaunt in command, Captain T. T. Grove, Lieuts. R. A. Turner, and W. F. Hanna and 2nd Lieuts. I. S. O. Playfair and A. M. Jackson. C.S.M. J. Redmore was the Company Serjeant Major; C.Q.M.S. Hobbs, Farrier Staff Serjt. T. Dawson and Serjt. Lukehurst were the senior mounted N.C.O.'s; and Serjts. Haggertay, Cahill, Fern and Park, Nos. 1, 2, 3 and 4 Section Serjeants respectively.

The Company left Moore Park for Queenstown on August 19th and, embarking on the S.S. *Maidan* on the 21st, sailed at 4 p.m. that day.

*Cambridge.*—The next morning found them, much to their chagrin, arriving at Liverpool, whence they proceeded into camp at Cambridge with the remainder of the 6th Division. Training with Brigades was then carried out until September 7th, when the Company marched to Royston (moving off within 20 minutes of receiving orders) and entrained for Southampton, where they arrived at 2.30 a.m. on the 8th and embarked on S.S. *Oxonian*, which sailed the same day.

*France.*—On September 10th the *Oxonian* arrived at St. Nazaire, and at 1000 hours the Company disembarked and proceeded to camp at Grand Marais.

On the 11th they entrained at St. Nazaire for an unknown destination and detrained the next day at Marles, near Coulommiers, whence they marched in a downpour of rain through the forbidding Forest of Crécy to Ferme de Bessy, about nine miles. The cyclists of No. 1 section were sent on ahead as an advanced guard, as it was thought that small parties of the enemy might be about, having been left behind by our own troops in their advance of a week previously.

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No enemy were met, however, and the Company went into their first billets in the theatre of war at Ferme de Bessy in the best of spirits in spite of the rain.

On the 13th the Company marched to Jouarre (13 miles) where No. 1 Section, under Lieut. Turner, was put on outpost duty as infantry, while the remainder billeted in a convent. Nothing occurred during the night, however, and the next day, the pontoons having been sent to the 38th Company, the march was continued to Saacy, and on the 15th the Company marched with the Main Guard of the 6th Division *via* Château Thierry to Rocourt, a distance of 23 miles, where, after another march in the pouring rain, they bivouacked in a ploughed field at 11 p.m. !

The 6th Division was to have supported an attack by the 1st Corps on the Chemin des Dames, and the Company accordingly marched at 0600 hours on the 16th with the 16th Infantry Brigade to Buzancy, five miles south of Soissons, where they bivouacked just east of the village. (See *Map* II.)

In the afternoon Captain T. T. Grove made a reconnaissance of the ground between Billy and Belleu with a view to the construction of a defensive line.

At this time it was found that, as many units had lost equipment in the recent retreat, tools for parties working on the construction of the trench systems, which were now just beginning to become a prominent feature of the war, were getting very short. Accordingly Lieuts. Turner, Playfair and Jackson were sent out with parties to requisition picks and shovels from the inhabitants in Rozières, Septmonts and Noyant, as a result of which 140 shovels and 30 picks were sent to the 4th Division Headquarters at Serches, the G.O.C. 16th Infantry Brigade expressing his satisfaction at the numbers collected.

During the next two days reconnaissances of the proposed defensive line about Venizel and Villeneuve were carried out and barbed wire for obstacles was collected

On the 19th orders were received that the 12th Company was to remain with the III Corps to prepare positions in the neighbourhood of Belleu and Acy. The bivouac was then moved to Septmonts and the next day work was begun with the Royal Welch Fusiliers on the trenches in the new positon.

On the 21st the Company was ordered to Bazoches, 12 miles distant, and on arrival there was told to proceed to Mont Notre Dame, a further three miles, where further orders were received to go on to Paars, on the march to which place they were met by a Staff Officer and ordered to return to Mont Notre Dame to build a ramp for detraining 6-in. howitzers. This was finished on the 22nd, and was about 30 yards long, consisting of a crib-work of sleepers dogged and spiked together, with rails spanning between, and decked with 2-in. planking.

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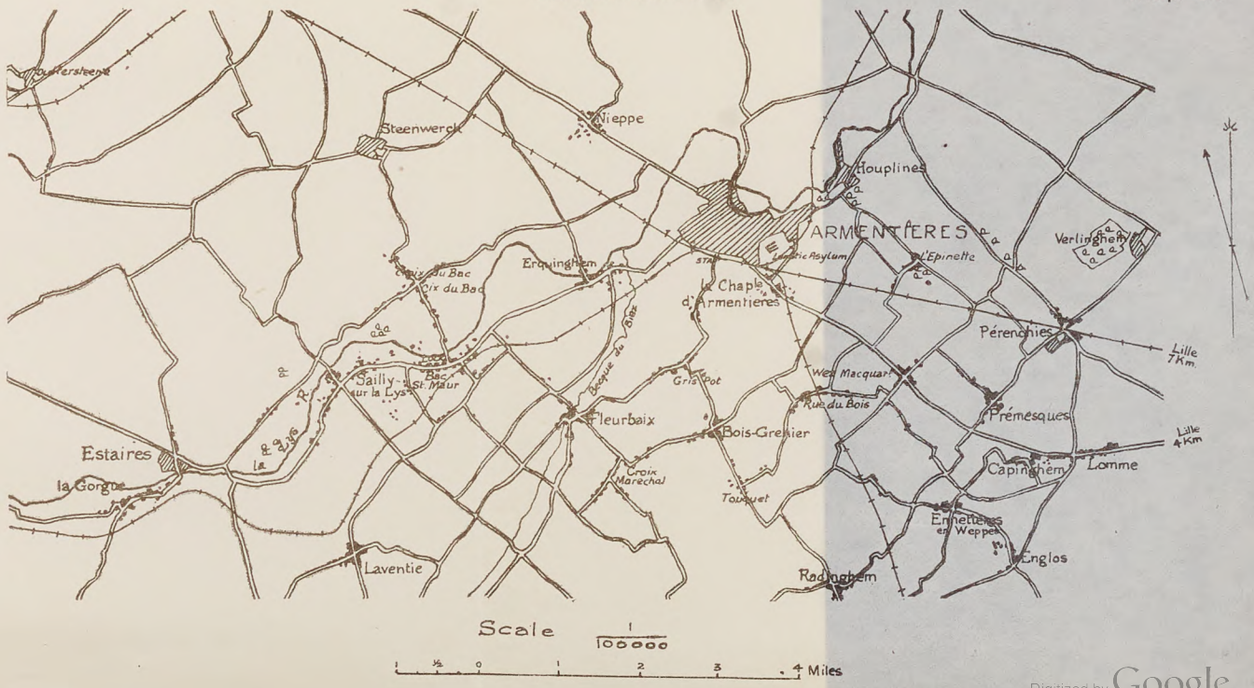
## THE AISNE.

Map II.

## ARMENTIERES.

Map III.

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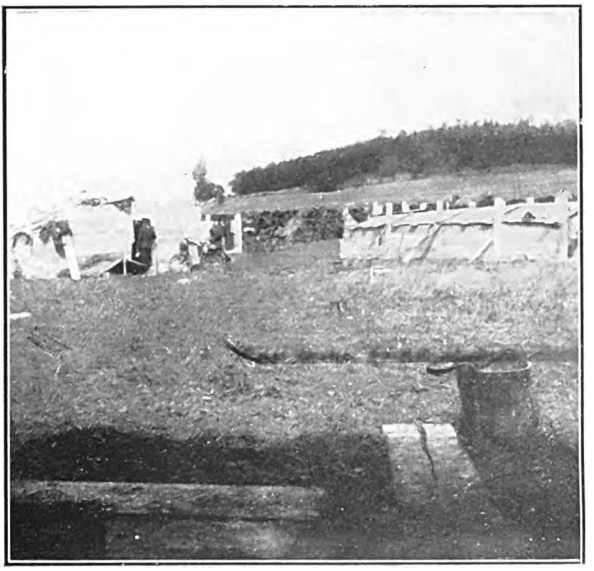
# HISTORY OF THE 12TH COMPANY, ROYAL ENGINEERS.



Company's bivouac on the march up to Soissons; made of planks, but with no nails!

Company's bivouac at Vailly. The front line is just on the skyline above the sandpit.

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Bridge over R. Lys at Bac St. Maur damaged by floods.

Bridge repaired.

In the line near Armentières. Lieut. A. M. Jackson having a shot at the Hun!

Breastworks in Flanders. Winter, 1914-15.

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On the 23rd, the Company marched to Bazoches and then on to Braisne, joining the 3rd Division and relieving part of the 56th and 57th Field Companies at Vailly. In the evening the Company, less one section, moved up to their bivouac in a sandpit some 200 yards behind the front line near Rouge Maison, leaving all the transport except two single tool-carts and the water-cart in the woods south of Chassemey, under Lieut. Playfair. One section remained in Vailly working with the 8th Infantry Brigade, and also on the repair and maintenance of the pontoon bridge, alongside the road-bridge which had been partially destroyed by the Germans in their retreat.

The Company lived in "burrows" in the sandpit, which gave good protection from enemy fire, and remained here until October 3rd, working nearly all day and most nights on trench work, drainage, wiring, sapping and listening for supposed German mining. Nearly all the barbed wire and posts for the obstacles had to be collected by day and prepared for erection at night.

On October 3rd the Company suffered its first casualties. A party of No. 4 Section were wiring under cover of the early morning mist when it lifted suddenly, exposing the whole party to the enemy's view. Before there was time to take any action heavy shrapnel-fire was opened upon them, Sapper Byrne being killed and four others wounded.

*Move to Flanders.*—The move of the British Army to Flanders had now begun, and that evening the Company moved to Dhuizy near Serches. A retreat at this time appeared imminent and on the 4th a retired position was reconnoitred and some bridges over the Vesle were prepared for demolition by the Right Half-Company.

On the 6th the Company marched to Nampteuil, the Left Half-Company taking up the pontoon bridge at Missy, consisting of five pontoons and a trêstle, after the last British infantry had crossed. The Company then continued its march *via* Vouty, Fresnoy, and Longueil St. Marie to Estrées St. Denis, where they entrained at 1100 hours on the 10th, arriving at 0850 hours the next day at Arques, where they detrained and moved into billets.

*Advance Eastwards.*—The whole of the 6th Division was now in the St. Omer area, and on October 12th they advanced in the direction of Hazebrouck, the 12th Company marching with the Advanced Guard at 0525 hours, one section being with the Van Guard. It was very foggy and all troops marched with bayonets fixed.

After many delays the Company finally halted at Pradelles, where they billeted. The advance continued the next two days, and, although the Infantry in the advanced guard had some sharp fighting near Merris, there was practically nothing for the Sappers to do until the 15th, when the Company left Oulterstreene, where they had been billeted, and marched *via* Les Trois Fermes,

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Blanche Maison, Steenwerck and Croix du Bac to Bac St. Maur (see *Map* III), where the 1st Battalion Leicestershire Regiment were held up by the River Lys.

There was a swing-bridge at this point which the Germans had left open but had not destroyed. As it was worked from the far bank, Pioneer Dunford of No. 4 Section swam across with a cable, climbed up the central pier, and made it fast to an extremity, after which the bridge was pulled to. The Infantry then advanced and reconnaissances were made for the defence of the bridge.

On the 17th the Company marched with the 24th Brigade R.F.A. and billeted at La Vesée, work being begun at once on defences of all kinds in the sector of the 16th Infantry Brigade.

Very heavy fighting was at this time taking place round Premesques, Radingham and Pérenchies, during which reconnaissances were made and defence works carried out, usually under very heavy fire.

On the 20th the British fell back before the heavy German attacks, and after digging hard at Wez Macquart, the Company were ordered to move back and prepare positions during the night for the 16th Brigade about half-way back along the road to Armentières, where, in spite of the impossibility of sighting the trenches, owing to the darkness, work was begun at once. For a very long time after this these trenches remained the British front line in this sector.

Trench work was now begun in earnest, and the Field Companies settled down to what was probably the most trying period of the war for the Royal Engineers. Nearly all the trenches were in short, disconnected lengths; supplies were exceedingly short, there were only two Field Companies to a Division, and, in addition to collecting and preparing material by day for erection as defences by night, the Sappers were called upon many times to man the trenches.

On the 24th billets were moved to Fleurbaix.

The Company continued working all day and most of the night on trenches, wiring, barricades and rear defence lines. About the end of the month the scheme of making up wire entanglements in "sets" before erecting was introduced, thus lessening the time and labour necessary for actual erection in the front line.

On November 2nd the Company relieved the 20th Company R.E., in work on the rear line. Large civilian gangs were employed on this work under the supervision of a few N.C.O.'s and Sappers. Working under their own foremen (*chefs d'équipe*) and with their own extraordinary tools, they were able to excavate far more than could our own Sappers with G.S. shovels! These gangs, under one N.C.O. and two Sappers, undertook the whole construction and revetment of a complete second-line breastwork.

As the Company's billet was beginning to receive an unpleasant amount of attention from the enemy, it was moved to a farm on the

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Rue de La Lys, near Erquingham, where workshops were started and the system of having two "forward sections" was instituted, the forward billet being in Bois Grenier.

About this time experiments with rifle grenades and trench mortars were carried out, and large quantities of hurdles, trenchboards, fascines, etc., were constructed in the workshops in back billets.

*Inspection by Lord Roberts.*—On November 12th the Company paraded and were inspected, on the occasion of a visit to their billets, by Lord Roberts, who expressed his appreciation of their appearance and work during the past months.

On November 13th a party under Lieut. Turner blew a gap in the Armentières-Lille railway near Porte Egale Ferme, and on the 17th another party, under Lieut. Playfair, repaired the line from Armentières to Rue du Bois in order to be able to bring rations, stores, etc., up to the front line in trucks. Lieut. Turner subsequently carried out further demolitions in front of Rue du Bois.

On the 19th November the wooden wire-bound trench mortar with which experiments had been made was fired successfully—thus marking a step in the evolution of one of the nowadays numerous trench-warfare weapons. Jam-tin grenades were also made in some quantity towards the end of the month.

*Mining Started.*—On the 21st mining operations were started in the trenches of the Durham Light Infantry near the Rue du Bois. A trestle bridge of five spans over the River Lys was also constructed to replace the pontoons in position at Bac St. Maur.

The same work of mining, draining, construction of shelters, fascines, etc., continued during December, and as the severity of the winter increased, breastworks began to take precedence over everything else. The Company put up literally miles of breastwork revetment, and until the end of the year practically nothing occurred to vary the usual routine of trench work.

On December 26th the 1st London Field Company R.E. (T.F.) arrived as the third Field Company with the 6th Division, and were allotted to the 16th Brigade, the 12th Company taking over 17th Brigade work.

*The "Truce" at Christmas.*—About Christmas, and for some little time afterwards, occurred the informal "truce," during which time work was carried on in the open by day by both sides; and often at night, when an enemy searchlight was playing on our men, not a shot being fired by either side. This did not last very long, however, and the old state of things was soon reverted to.

*Armentières Asylum.*—On January 1st, 1915, the Company moved to the Asylum in Armentières, which, though conspicuous, proved a very comfortable billet.

On January 3rd a ruined house in "No Man's Land" was demolished successfully with explosives, and on the 23rd a barrel-pier

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bridge was constructed across the moat of Porte Egale Ferme; otherwise the work continued the same as before, the daily programme being more or less as follows:—If night work had finished by 0200 hours, the first working parade was at 1030, the men having cleaned up as far as possible. If night work had lasted till after 0200, the first parade was at 1400. The men then worked till 1700 and paraded again for night work at 1900 hours, thus probably working 12 or 13 hours a day. This naturally proved too trying to last, and it was therefore decided that Sunday should be a rest day.

On February 3rd and 10th the asylum was heavily shelled, and seven men were wounded on the first and several more on the second occasion, Bugler Hayles subsequently dying of the wounds he had received. On the latter occasion great gallantry was displayed by Lance-Corporal Morgan in rescuing wounded men from a burning building which was full of poisonous fumes, for which act he subsequently received the Distinguished Conduct Medal.

Soon after this, instruction in fieldworks was given to Infantry and also to Canadian Engineers, preparatory to the latter occupying the line.

*L'Epinette.*—During the early days of March a considerable amount of sapping was carried out to provide "jumping-off" trenches for the attack on L'Epinette, which was shortly to take place. L.-Cpl. Driver showed great courage and resource in this work and was awarded the Distinguished Conduct Medal and Russian Order of St. George.

On March 10th the Company paraded at 2200 hours for the attack on L'Epinette, which was to be made by two Companies of the 1st Battalion North Staffordshire Regt.

Lieut. Turner and ten men of No. 1 Section were allotted to the right, and Lieut. Jackson and ten men of No. 2 to the left, assaulting column; the remainder of Nos. 1 and 2 Sections going with the working parties of the right and left columns, while Nos. 3 and 4 Sections followed the right and left columns to help in consolidating.

The attack proved neither hazardous nor very exciting, as the enemy made practically no stand, and the village was entered very easily, the Company's casualties being only two wounded and one missing.

The work of the Company then consisted of constructing loopholes, linking up houses by means of trenches, and wiring. During the following days, however, various counter-attacks were launched by the enemy and the work of consolidation was often carried out under very heavy fire. Lieut. Turner was wounded on the 12th. On one occasion a small party of No. 2 Section under A/Serjt. Rouse were suddenly heavily attacked by a German bombing party—but after some sharp fighting they accounted successfully for all the bombers. Serjt. Rouse was awarded the D.C.M. for his conduct in this action.

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YPRES. Map IV.

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On the 29th, 2nd Cpl. Byrne (No. 4 Section) was in charge of the work of erecting a machine-gun emplacement in a very exposed position in the front line some 120 yards from the enemy, who were sniping and firing continuously the whole time the work was going on. In spite of the difficulties, however, it was completed satisfactorily and for this 2nd Cpl. Byrne received the Distinguished Conduct Medal.

At the beginning of April, C.S.M. J. Redmore, in company with several other R.E. Warrant Officers, was given a commission and left the Company.

The usual routine of trench work was carried out during April and most of May, and nothing unusual happened until, at the end of the month, the 6th Division moved up to the Ypres salient to relieve troops which had suffered so heavily in the recent second battle of Ypres.

*Move to Ypres Salient.*—On May 28th the 2nd Wessex Field Company R.E. (T.F.) arrived to take over the sector from the 12th, who marched out that day *via* Nieppe to Bailleul, subsequently moving on the 31st to Camp " A," a hutted camp near the Ypres–Vlamertinghe road. (See *Map* IV.)

The 18th Brigade, with whom the Company were now working, had moved into the line at Potijze, and for the ensuing period work was carried out on the defences of the ill-famed Potijze–St. Jean sector, consisting mainly of machine-gun emplacements, dug-outs for headquarters, revetments, wiring, the construction of duckboards, etc., at back billets, and the repair of the roads with the remains of Vlamertinghe village !

The forward sections were billeted in dug-outs in the bank of the Yser Canal, and with the help of doors, planking, etc., from Ypres, made themselves fairly comfortable.

Civilians were now again employed in the Company shops.

The billets were soon moved to a field just west of Vlamertinghe.

*Attack near Railway Wood.*—On June 14th and 15th preparations were made to support the 3rd Division in an attack they were going to make near Railway Wood, scaling ladders being made, assembly trenches dug, etc.

The attack was launched at 0415 hours on the 16th, No. 2 Section being with the supporting Battalion near the railway. Practically nothing happened, however, though No. 2 Section had three men wounded.

The 6th Division front was continually being altered and the Company worked on various sectors from Morteldje (opposite Pilkem) down to the Zillebeke front.

By June 26th an engine and circular saw were installed at the Company workshops.

On July 12th Lieut.-Colonel Sargeaunt handed over command of the Company to Captain A. Campbell, the adjutant, and became

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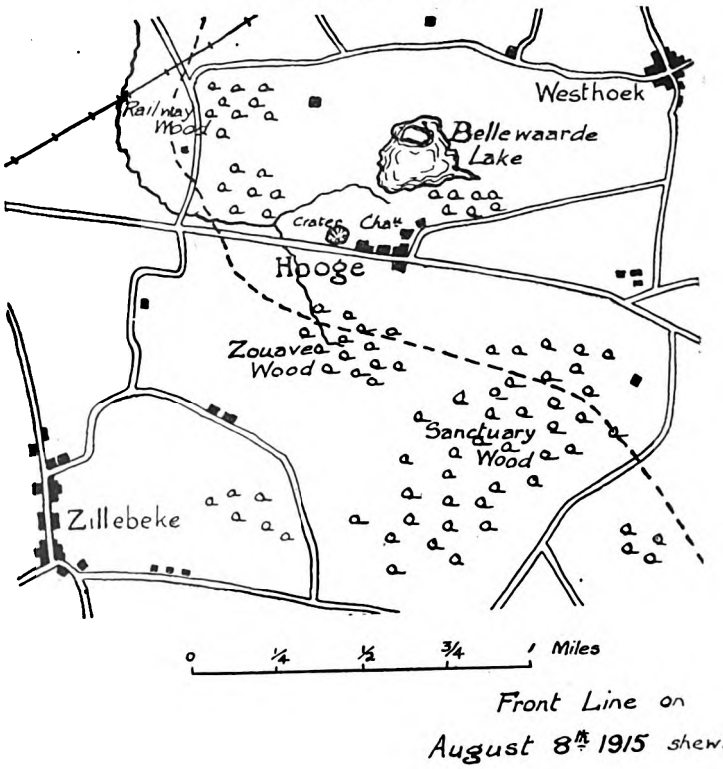
C.R.E. 14th Division, which appointment he was holding when he was killed on 31st August.

During July there was considerable activity in the Hooge sector, and the Company sustained several casualties, among the wounded being Lieuts. Baines and Jackson.

*Hooge Crater.*—On the 19th a huge crater was blown under a German redoubt at Hooge, and was captured by the 6th Division, but on the 30th, after the 6th Division had been relieved, the enemy launched a heavy counter-attack, and, with the help of their new *Flammenwerfer*, succeeded in not only recapturing the crater, but also part of our original front line. After an unsuccessful counter-attack by the troops then in the line, the 6th Division were ordered to take over their old sector and to recapture the lost ground. (See *Map* V.)

HOOGE AREA. Map. V.




Preparations were accordingly put in hand for the attack. All four sections of the Company lived in the ramparts in Ypres from the beginning of August until the attack, and worked hard on the preparations.

*Attack at Hooge.*—Nos. 1 and 3 Sections and 24 other N.C.O.'s and men of the 12th Company took part in the attack on the crater on

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August 9th, Captain A. G. Turner being in command of the R.E., with Lieuts. Sibeth and Frecheville.

The 16th Brigade, with the 1st K.S.L.I. on the left, 2nd York and Lancs in the centre, and the D.L.I. on the right, were to advance in a north-easterly direction from Zouave Wood against the crater, which was about 500 yards distant, just north of the Menin Road.

The first line of attack consisted of bombers accompanied by four parties, each of one junior N.C.O. and three sappers, to help in blocking communication trenches. Each party carried a wooden loophole, a coil of French concertina wire and shovels, and each man had six sandbags tied to his belt.

The remainder of the 12th Company's party followed with the 2nd Battalion York and Lancaster Regt. and 1st Battalion K.S.L.I. in the second line of attack, to consolidate and erect obstacles.

The attack was launched at 0315 hours after a heavy bombardment. The casualties were heavy from the start, a large number of men being knocked out before reaching the enemy's line. The front and support lines were, however, taken, and the trench blocking parties at once got to work, blocking the communication trenches leading to the enemy's position and helping the infantry to repel constant bombing attacks.

As soon as our troops had captured all their objectives the consolidating and wiring parties started work under extremely heavy fire; carrying out wiring and digging communication trenches in the open in spite of the enormous difficulties and heavy casualties. Work was continued until nightfall, when the survivors, numbering only about 15, withdrew, and the remainder of the Company came up to continue the work of consolidation.

The losses of the 12th Company had been very heavy indeed, for out of three officers and about 60 other ranks who took part in the action, the casualties were: 1 officer (2nd Lieut. Sibeth), and 18 other ranks killed; 2 officers and 18 other ranks wounded, and 9 other ranks missing (believed killed), being 100 per cent. of officers and about 75 per cent. of other ranks.

As a result of their work the R.E. were specially mentioned for their gallantry by the G.O.C. 6th Division in his report, and the following letter was received from the G.O.C. 16th Infantry Brigade—

Commanding Royal Engineer,
6th Division.

The following is an extract from a report by Lieut.-Colonel Clemson, Commanding 2nd York and Lancaster Regt., on the action at Hooge on the 9th instant:—

"The excellent work done by the section of the 12th (Field) Co., R.E. "(under Captain Turner and Lieut. Sibeth). This section went forward "with the second line and moved through our first line under very heavy "artillery and machine-gun fire, and put up wire in front of the captured

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"position. I regret their losses were very heavy—both officers were "wounded, but the remainder of the men still went on working and "when the wire was finished came back and dug communication trenches "in the open. I cannot speak too highly of their work, and this section "had the admiration of all for their bravery and coolness under the very "heavy fire."

Major Luard, Commanding 1/King's (Shropshire Light Infantry) also told me of the excellent work of the detachment 12th (Field) Co., R.E., who were with his Battalion.

I should be much obliged if you would let the 12th (Field) Company know of this, and of how much their work has always been appreciated by the 16th Infantry Brigade during the many months in which we have worked together during the war.

L. NICHOLSON, *Brig.-General*,
12/8/15. Commanding 16th Infantry Brigade.

Captain Turner was awarded the Distinguished Service Order, and L.-Cpl. Dowe and Sapper Jackson both received the D.C.M. for their gallantry during the action.

During the next fortnight the work of consolidation was carried on, nearly always under extremely heavy fire. The casualties were again very severe, 9 other ranks being killed and 3 officers and many other ranks wounded.

*Inspection by General Congreve.*—On August 24th the Company was at last moved out to Houtkerque for a well-earned rest. Here they remained until September 3rd, receiving reinforcements and reorganizing, during which time they were inspected by the G.O.C. 6th Division (Major-General W. N. Congreve, V.C.), who expressed his great appreciation of the work of the Royal Engineers in the recent Hooge operations.

On September 3rd the Company moved into the line once more, going up from Houtkerque by bus, two sections going into billets on the canal bank and the others into back billets south of Oosthoek.

Subsequently the headquarters and one other section moved up to the canal bank, while one section remained in back billets manufacturing material for the trench work, etc., on which the forward sections were engaged.

The Company remained thus for the rest of September, the whole of October and part of November, the work consisting, in the front line, of the usual reclamation, draining and repairing the sodden ditches which the trenches had become in the Verlorenhoek-Hooge sector, constructing shelters, machine-gun emplacements, trench tramways, etc., and, further back, on the upkeep of bridges and dug-outs on the canal, and the defences around Potijze.

On November 18th the 6th Division went out into rest, and the Company had their billets first on the Ypres-Poperinghe road and afterwards at their wagon lines on the Elverdinghe–Poperinghe road.

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They remained here working on the improvement of back billets until December 15th, when they moved up once more, the forward sections taking over their old dug-outs in the canal bank.

For the next three months the Company remained here, carrying on the same work as before, and although no active operations were undertaken during this period, casualties were again heavy owing to the continual harassing fire and the very exposed nature of much of the work, 5 other ranks being killed and 3 officers (Lieuts. Playfair, Regnard and Ivory) and many other ranks wounded.

On March 15th, 1916, the Division being once more relieved, the Company marched back to Herzeele, where they rested and carried out pontooning and other training, and were inspected by the C.-in-C. on March 21st. On the 27th they moved to Calais, where they remained for four days before returning to Herzeele, where they carried out further training, in addition to giving instruction in fieldworks to the 11th Battalion Leicestershire Regt., which had joined the Division as Pioneer Battalion. This was no light task, as none of the officers or men had been on active service before and most of them had but recently been recruited. They were all very keen and eager to learn, however, and very soon an excellent liaison had sprung up between the Divisional R.E. and the Pioneers which lasted till the end of the war. An extensive reconnaissance of the Wormhout–Poperinghe area, to ascertain the extent of the water supply of the district, was also carried out in anticipation of an attack on the Pilkem Ridge later in the year.

On April 17th the Company moved up into the line again, taking over work in the 18th Infantry Brigade's sector opposite Boesinghe and adjoining the French.

The work was the same as on the previous occasions, with the addition of carrying out extensive renovations to the trench tramway system. This was interesting though difficult work, as the formation had, in many places, to be carried over swamps and marshes 50 to 60 yards in extent, and had to be capable of acting not only as a tramway formation but also as a track to and from the line. When completed this was the chief means by which rations, ammunition, stores, etc., were taken up as far as the support line.

During this time most of the working parties were subjected to heavy machine-gun fire, and the back billets were often heavily shelled, the casualties in consequence were high.

*Attack near Boesinghe.*—On the night of 3rd–4th June a small operation was undertaken to improve the alignment of the front on the extreme north of the sector, and to capture certain enemy posts which were enfilading the support line.

Nos. 1 and 4 Sections (Lieuts. Osmaston and Johnson) took part under the command of Captain A. Campbell. No. 1 Section was detailed to wire in the flank after the capture of the objectives,

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and No. 4 were, with the help of some pioneers, to cut a communication trench through to the new position.

The attack was entirely successful, the objectives being reached at 2300 hours. No. 1 Section's work was then successfully carried out under very heavy machine-gun fire, and in spite of being wounded Lieut. Osmaston showed great courage and perseverance, remaining at the work until it was completed the next day. No. 4 Section also carried out their task satisfactorily. As a result of the gallantry they had displayed during the action Captain Campbell was awarded the D.S.O. and Lieut. Osmaston the Military Cross.

On the 16th the Company marched out to rest at Herzeele and on the 18th moved to Volkeringhove. Here, during the next ten days, an exact replica of the trenches on Pilkem Ridge was constructed, over which the Guards and 6th Divisions carried out practice assaults in anticipation of a combined attack subsequently to come off at Pilkem. Although the 6th Division did not eventually participate in the attack, this work formed the basis for the attack which was carried out by the Guards and Welsh Divisions in July, 1917.

On July 1st the Division again went into their old sector, and for the remainder of the month, with the exception of four days' rest west of Poperinghe, the Company carried out the usual work in the line and on rear defences. From the 15th to the 30th the two forward sections were billeted in cellars in Ypres. On the 31st the Company left the line and marched back to rest west of Poperinghe.

The 6th Division had now been exactly fourteen months continuously in the Ypres Salient, during which time, although there had not been many active operations by or against the enemy, the casualties had been very high and the experiences they had been through extremely trying. Nearly the whole of the salient was overlooked by the enemy's positions on the high ground in front, and a great deal was subject to enfilade fire from the flanks. The trenches in which the men had had to fight and work were mostly little more than shattered breastworks or waterlogged ditches. This meant also that the R.E. work was, with a few exceptions, of a most monotonous and trying character, having nearly all to be carried out at night, and, as all the roads and tracks in the salient were nearly always under heavy fire from both artillery and machine-guns, the working parties, on their way up to or on return from the line, went through very trying times and suffered severely.

*The 6th Division Leave Ypres Salient.*—It was therefore without many regrets that the Company entrained at Proven on August 3rd and said " Good-bye " to the places they had got to know only too well during their lengthy spell in the Salient.

(*To be continued.*)

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# *MEMOIR.*

## *LIEUT.-GENERAL SIR RONALD C. MAXWELL, K.C.B., K.C.M.G., COLONEL COMMANDANT, ROYAL ENGINEERS.*

### FOREWORD.

IN submitting the accompanying Memoir to his brother officers, the compiler wishes to express his thanks to those without whose aid the story could never have been told.

Firstly, to Lady Maxwell and the members of the Maxwell family, with a special word to Mrs. Hammersley, of Ridgeway, Lymington, the Henrietta of the Malta days, who, at an advanced age, retains such vivid and affectionate memories of Ronald's parents.

Secondly, to many officers outside the Corps who have helped, commencing with Field-Marshals the Earl of Ypres and Sir William Robertson, and including Colonel Evan Gibbs, R.A.S.C., and other members of Maxwell's staff who furnished the vivid accounts of his life at G.H.Q.

Finally, to the large number of brother officers who have filled in the picture as regards service in the Corps, and the terms of whose letters give such touching proofs of the affection which Ronald Maxwell inspired and which is still warm in so many hearts.

*November 5th*, 1924.

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RONALD MAXWELL'S paternal grandfather was William Maxwell, of Carriden, near Linlithgow, an estate which his father had purchased with a fortune made in the West Indies, where he had considerable property in Antigua and Grenada. William Maxwell, who was born in 1768, and educated at Westminster School and Oxford University, entered politics at an early age as Member of Parliament for Linlithgow. He was a consistent Whig and a firm friend and supporter of Fox, Grey and Burdett. True to his principles, even when they were to his personal disadvantage, he was an ardent advocate of the abolition of slavery which ruined his estates in the West Indies and ultimately led to his selling Carriden.

As a young man, when reading with a Protestant pastor in Switzerland, he made the friendship of another boarder, Edward Bouverie, eldest son of the Hon. Edward Bouverie of Delapré Abbey, in Northamptonshire. This friendship led to Maxwell's making the acquaintance of and ultimately marrying his friend's sister, Mary Bouverie, in 1800. She died in 1816 and their eldest surviving son, born in 1806 and called Charles Francis, after his father's friends, Fox and Burdett, was the father of Ronald Maxwell.

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Charles Francis Maxwell, after being educated, like his father, at Westminster School, entered the Army in 1825 as an Ensign in the 82nd Foot and became a Captain in 1832, but we first come in touch with him in 1837, when he went to Malta, as Military Secretary to his uncle, Lieut.-General Sir Henry Bouverie, G.C.M.G., K.C.B., who became Governor of the Island in that year.

Sir Henry, some years younger than his sister, Mary Maxwell, and sixteen years younger than his eldest brother Edward, had had a distinguished military career, first in the Coldstream Guards and afterwards on the Staff; at the age of nineteen he commanded a Company at the battle of Aboukir Bay, was taken prisoner in a subsequent sea-fight, was at the siege of Copenhagen in 1807, and was present at most of the principal engagements in the Peninsular War, part of the time as A.D.C. and Assistant Military Secretary to the then Sir Arthur Wellesley.

Charles Francis who, from all accounts, was a most delightful and engaging person, was an immense favourite with the veteran General, who regarded him more as a son than a nephew.

In the early days of his service at Malta he met and fell in love with Thomasine Ionia, the daughter of the Colonial Secretary, Sir Frederick Hankey, G.C.M.G., a beautiful and attractive girl, as clever as she was beautiful, and as good as she was attractive. Her mother had been a lady of Corfu, of an old Venetian Ionian family, and from her Thomasine inherited her good looks and much of her peculiar charm.

The attraction between Charles and Thomasine was mutual, they were married at home in 1839 and came out to Malta and began their happy married life in a little house in the Palace Square, adjoining the Governor's residence. Here the two eldest of their children, William and Catherine, were born, and here Mrs. Maxwell helped to mother Henry and Henrietta, the two children of Sir Henry, whose wife had died before he went to Malta. These children adored cousin Charles and his fascinating wife, and one of Henrietta's happiest recollections is of the days when the young couple used to take her, mounted on her Egyptian donkey, out riding with them.

We get a last glimpse of this pleasant party when the time came for home and they made their way there overland: the Maxwells and their children drove in one carriage, "Uncle Harry," his boy and girl with their nurse, in another. What adventures they must have had, and what sights they must have seen as they posted north through beautiful Italy and its entrancing cities; through Rome and Milan, over the Alps to the Black Forest, and so to the Channel and home.

The party broke up after reaching England, when Charles resumed regimental duty, and here we must take leave of Sir Henry, who, after refusing further employment, settled down, partly in Eaton Square and partly at Woolbeding, in Sussex, where he joined forces with his widowed sister, Mrs. Pousoutry. At both places the Maxwells and their increasing family were constant and welcome visitors until Sir Henry died suddenly in 1852, when preparing to attend the funeral of his beloved chief, the Duke of Wellington.

His only son was killed as a Captain in the Coldstream Guards at

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the battle of Inkerman, but his daughter Henrietta still lives, and to her clear recollection we owe this memory of bygone days.

Charles soldiered at home for another eleven years, was Brigade-Major at Plymouth for a year in 1846–7, got his majority in 1847 and commanded his battalion on home service until he sold out in 1854.

Meantime the happy marriage was having plentiful results, and when Ronald was born at Blois, on December 26th, 1852, he was the seventh child—five more were to follow, Cedric, the next, being born in 1854, and the youngest, ten years later, in 1862.

After Colonel Maxwell left the Army the family lived for a time in Scotland, but to a larger extent abroad, partly for economy and partly to teach the children languages.

They were constant visitors, however, at Delapré, which the boys, when at school, got to look on as a second home. Uncle Edward was as kind as Uncle Harry, whilst General Everard Bouverie, who reigned at Delapré after his father's death, helped his cousin with the schooling of the increasing family and at his death left the bulk of his fortune to him he had loved so well.

Of the Maxwells' life abroad we get occasional glimpses, and of how boldly the mother used to pilot her brood all over the continent. She was an accomplished linguist herself, and used to make a practice of talking to her children, sometimes in one foreign language, sometimes in another; a friend of Ronald remembers going to see her as late as 1874, and was struck by her wonderful facility, "talking to me in English, to Ronald in French, to another son in Italian, and, indeed, I am not sure she did not speak to her daughter in yet another language, turning from one to another with perfect facility."

We hear of the family at Freiburg from one who was studying there; he tells of "the indelible impression left on the mind by a very remarkable family, which exhibited a refined type of beauty that paired with a delightful courtesy." Never did father and mother do more for their children or with better results.

The eldest son, William, died as a Vice-Admiral in 1900; whilst the third, Everard, followed him in the Navy and, when a commander full of promise, died in 1892.

Of Frederick, who was Ronald's senior by three years, and of Cedric, we shall hear again as officers of Royal Engineers.

Nigel served in the Artillery and retired as a Major in 1902, whilst Aymer retired from the Royal Munster Fusiliers, in the same year, as Captain. The remaining son, Gerald, joined the Church, and died in 1915 as Superior of the Society of the Cowley Fathers.

Of the four daughters, one died in girlhood, whilst the other three, one a widow and two unmarried, are still living.

Of the parents, Charles Francis was the first to go, and died in London in 1873, and was buried at Ham on the Thames. Thomasine outlived her husband by twenty-seven years, dying in January, 1900. She spent the latter years of her life in London, and we get a glimpse of her in those days, frail and tiny to have been the mother of twelve children, but charming, clever and very distinguished, whilst to the

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end she carried traces of the beauty and attraction that won her husband's heart in those happy far-off days at Malta.

Little Ronald, already an adept in foreign languages, was sent to school at the age of twelve to the Royal Grammar School at Henley-on-Thames, where five of the brothers were educated under the Head-Mastership of Doctor Godby. He stayed at the school for six years, and a brother officer well remembers going down with Frederick to play cricket against the school and finding both Ronald and Cedric in the Eleven.

Ronald passed into Woolwich direct from school, being eleventh on the list, and he joined the Academy, then under the wise rule of Sir Lintorn Simmons, on August 6th, 1870. Besides playing cricket for the Academy, he quickly established a reputation, thanks to his up-bringing, as an excellent French and German scholar, whilst from the very first he was very smart in appearance and dress, much the best drill as well as a very good disciplinarian. As a result, and a very unusual result in those days, Ronald was selected to be Senior Under Officer in his last term over the heads of a good many more senior cadets, and in consequence he received the Sword of Honour on quitting the Academy. He also obtained the prize for German, was ninth on the list and obtained his commission in the Royal Engineers on 2nd November, 1872. A contemporary writes of Ronald in those days: "He was in the batch above me at the 'Shop,' and I carry in my memory to-day my admiration of him when he was Senior Under Officer: how handsome and débonnaire and smart he looked—an example to us cadets with his inspiring word of command on parade, so punctilious and exact in all his motions and yet with entire absence of 'side' or swagger. None more worthily gained the 'Sword of Honour' with his commission."

Ronald's commission was antedated to May 2nd, 1872, but he first joined at Chatham on January 1st, 1873, fifty-one years ago, when England, the Army and the School of Military Engineering were very different to what they are now.

Those were the days of knife-board omnibuses and hansom cabs, before lawn tennis had been invented or afternoon tea introduced; when golf was practically non-existent south of the Tweed; when all the best people in the Army, and out of it, wore side-whiskers or imperials, and when, in London, the lion on the gateway of Northumberland House still looked down upon Trafalgar Square.

In the Army, although Peninsular and Waterloo veterans were still plentiful, progress had begun, as thought had been stimulated by the Franco-German War. The great War Secretary, Mr. Cardwell, sat in Pall Mall, with the Commander-in-Chief still entrenched in his separate office at the Horse Guards, where Colonel Sir Garnet Wolseley had recently joined as an assistant Adjutant-General. Purchase had just been abolished, and the short-service system had been introduced. Autumn manœuvres had been held in 1871 and 1872, and the troops were very proud of being just armed with the then "it" of small arms, the Martini-Henry rifle. Officers' dress consisted of the tunic and the mohair-braided patrol-jacket, whilst the days of serges, and still more

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of service dress, were a long way off. As a concession to Prussianism, the pantaloon and high boot had just been approved for Mounted Officers, to replace the booted overall, but the latter remained in use for many a year to come.

In the Corps itself, the Mounted portion consisted of three troops: A (Pontoon), B (Equipment), C (Telegraph); there were 27 ordinary companies and no field companies; our association with the Post Office Telegraphs had just been commenced, and two companies carried out the work. The Submarine Mining Service was still in its infancy, that service which was to prove so scientific and so effective, which for years was to attract so many of the best brains and best game players of the Corps, and which Ronald was destined to bury 32 years later.

Sir Frederick Chapman was Inspector-General of Fortifications, and Colonel Browne, Deputy Adjutant-General. The School of Military Engineering, which a few years previously had been brought up to date by Sir Lintorn Simmons, was now basking under the genial rule of Colonel Gallwey. These were the days when the Corps developed its great success at games of all kinds. The Commandant, besides being an excellent racquet player, was a deadly opponent at pool; the Brigade-Major, Major Marindin, was also Captain of the football team, the Assistant Instructor in Field Works, Capt. Merriman, was the goal-keeper, whilst the Assistant Instructor in Surveying, Capt. Fellowes, in addition to being one of the best fast bowlers in England, had been known to make 24 runs from one over by W. G. Grace.

H. W. Renny-Tailyour was at his cricket zenith and it was then that that brilliant meteor, F. W. Bennet, was flashing aross the cricket sky. The Association Football Cup was won by the Corps in 1875, and our team had made itself famous in the football world by its northern tours, when it had played and defeated the best performers in England. Colonel J. M. Grant (father of the present Commandant), as Superintendent of Military Discipline, ruled the Barrack Square, where he had, as his adjutant, Capt. Bruce Brine, with a high reputation for efficiency and smartness.

Lastly, at this time a long and lanky youth, with a parrot for his companion, was occupying in barracks a back room, which he owed to the good will of its allotted owner, Capt. R. H. Williams. This young officer's name was Kitchener; at this stage, however, indications of future greatness did not appear on the surface, and had been recognized so far by only two people: one of these was Williams and the other was the Emperor Francis Joseph. With Williams Kitchener walked, talked, went to church and fasted, commencing a life-long friendship with one whose influence over the young was as remarkable as was Ronald's to be in later years.

Ronald Maxwell's time at the S.M.E. seems to have been marked by no special incidents: he played cricket and football, but, with the galaxy of talent then available, was not in the front rank; a contemporary and intimate friend of those days speaks of Ronald's joining in everything that was going on, socially and otherwise, and tells us that the reserve that was to mark a certain period of his later career had not then developed. The same friend tells us how well he remembered,

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when in camp at Wouldham in 1873, Ronald coming to tell him of his father's death; how grieved Ronald was, and how deep was the affection between father and son.

Ronald's brother Frederick, three years his senior, had left Chatham for Jamaica before Ronald joined, but Cedric came to Chatham a year before Ronald went to India and followed him there a year later.

Ronald left the S.M.E. on completing his course in November, 1874, but rejoined at Chatham in the following March for duty with the 27th Company under Capt. Peck, and stayed there until he sailed for India in the *Euphrates* on the 23rd September, 1875. He has left behind a vivid account of his experiences, of his interest and delight at a first glimpse of the East, of all the fun and characteristics of life on the old troopships. He landed at Bombay and was sent to Roorkee, where Colonel F. R. Maunsell was in command of the Sappers and Miners, with Capt. Bindon Blood as his Second-in-Command. We read in his narrative of the great review held at Delhi for the Prince of Wales (the future King Edward VII.), of the magnificence of the camps; of the native Rajahs, of the elephants with their silver howdahs and of the beautifully caparisoned horses. From Roorkee he went to Delhi with a Company of Sappers and Miners, and remained there until he joined the Public Works Department in August, 1876. At this period the officers of the Corps in India were, for the most part, so employed and had for long taken a predominating part in the great work of developing India as regards public buildings, roads, railways and irrigation. When Ronald went to India, of the 380 officer class officials in the Public Works Department, 300 were officers of Royal Engineers and but 50 R.E. officers were employed on purely military duties.

In those days the P.W.D. in India offered to the young officer the best, if not the only, chance of practice in the civil side of his profession, whilst officers so employed were always made available for military duty in case of war. It used to be alleged that officers detailed to Public Works were wont to deteriorate in military value, as well as to become slack and untidy in their personal appearance. This was doubtless true in some cases, but we can call to mind some very brilliant exceptions. Ronald was certainly one, as may be judged from the legend current in India that he used to wear starched collars in the hottest weather when others were wearing the softest they could find, and that even in the jungle, when camping alone, he made a point of always dressing for dinner.

Ronald was first of all posted to the Western Rajputana Railway at Ajmir, where he was for two years employed on construction work, after which he was sent to Calcutta as Assistant Director of State Railways, and nine months later we find him as Deputy Consulting Engineer for the Guaranteed Railways. In November, 1879, he was transferred to the Peshawar-Jalalabad Railway, and a month later his services were placed at the disposal of the Military Department for field service in the second phase of the Afghan War.

At this time Sir Frederick Roberts, after the action at Sherpur, was hardly pressed near Kabul, but his communications with Peshawar

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were being kept open by and in charge of a Reserve Division. To this Division Ronald was attached as Assistant Field Engineer, but, leaving Peshawar a month later for Lundi Kotal, he was appointed Adjutant, R.E., to the Division, the C.R.E. being Major George Hills, R.E. The Division was later collected near Kabul and became the 2nd Division of the Northern Afghanistan Field Force. Meantime, Sir Donald Stewart's force (with brother Cedric in command of a Company of Sappers and Miners) had marched to relieve Kabul and defeated the Afghans at Ahmed Khel on April 19th, and the second Division was pushed out from Kabul to lend them a helping hand.

Two and a half months later, on 27th July, came the disastrous action of Maiwand, followed by the Siege of Kandahar by Ayoub Khan. This led to the famous march from Kabul to Kandahar of a specially equipped force under Roberts. Ronald was one of the few R.E. subalterns who accompanied the force, and he acted as Assistant Field Engineer under Capt. Nicholson (later known to fame as Field-Marshal Lord Nicholson), and on the staff of the second Brigade, commanded by Brig.-General T. D. Baker. The force left Kabul on the 8th of August, and fought the battle of Kandahar on the 1st of September, where Maxwell was galloper to General Baker and was the first man into Ayoub Khan's camp. A fortnight later he marched to Quetta with the second Brigade, which was then broken up, and on the 5th of October, 1880, Ronald reverted to the Public Works Department. He had not the good fortune, like Cedric, to be mentioned in dispatches, but Colonel Perkins, C.B., C.R.E. to Sir Frederick Roberts, sent in a very commendatory report on Ronald's work, and so ended satisfactorily his first essay at active service.

The next two years were spent as officiating Deputy Consulting Engineer at Lucknow, and it was while he was so employed that a brother officer ran across him at Allahabad railway station in great distress, having just returned from Secunderabad, where his brother Frederick (who had come to India in 1876 and had since been employed on railways), had been killed in an accident at polo. From Lucknow he was moved to the office of the Director-General of Railways at Calcutta, and, working between Calcutta and Simla, he stayed at this employment until January, 1885, when he accompanied Colonel Sanford, D.Q.M.G., India, on a reconnaissance up the Bori valley for a road from Dera Ghazi Khan to the Pishîn plateau above Quetta. Then came the Pendjeh scare and Maxwell found himself nominated as Adjutant, R.E., to the first Division of the Army Corps it was proposed to assemble, and in the meantime he was lent as personal assistant to the Chief Engineer of the Bolan–Hurnai railway, which was to be rapidly constructed to help the advance of the Army being collected in India. On this work Maxwell served for six months in great heat and discomfort, and through a terrible outbreak of cholera, which wrought havoc among the large collection of native workmen. For some time Maxwell had to act as doctor with the aid of a native apothecary, and as parson to bury the European subordinates who succumbed. A brother officer writes of this period: "When ordered from Quetta to Meerut, I drove down the Bolan in June, 1885, at a time when cholera was very

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bad and my carriage companion was in a mortal funk. On reaching the foot of the pass at Sibi, we had to wait for the train ; my companion would not quit the station, but sat with a disinfectant applied to his nose. It was very hot and a dust-storm was blowing, but I went to the R.E. tent and found Ronald and Oldfield . . . Their cook and groom had just died of cholera, but they were quite cheerful and gave me a decent dinner. It was about the most horrible place I had been in, but Ronald never groused or complained."

In due time the doctor arrived, the cholera wore itself out, and the war scare died away, and so it came about that Ronald sailed for home from Karachi on long furlough in October, 1885, just ten years after he had first arrived in India. A very complimentary report followed him home, speaking both of his capacity in office work and as to his energy and ability in construction.

It is interesting to note that for five years, from 1876 to 1881, Frederick, Ronald and Cedric were serving in India together. Cedric did all his time with the Sappers and came home in the same year as Ronald.

During his ten years of Indian service Ronald had two periods of privilege leave (three months), one of which he spent with his mother and sisters at Wiesbaden, in 1881, and the other, three years later, he devoted to a visit to Australia.

Ronald had a much-needed rest when he reached home. Some of the time was spent in travelling in France, Italy and Germany, and six months in working at Gregson's for the Staff College Examination, for which he went up in 1887. It was a difficult year for Sappers, as eight qualified for three vacancies. Captains Bethell and Sinclair were first and second on the general list and Capt. Leverson, coming tenth, got the third engineer vacancy. Ronald Maxwell and George Scott-Moncrieff were respectively thirteenth and fourteenth, and only 45 and 55 marks behind Leverson. Ronald had an attack of fever during the examination and has said that but for it he would certainly have got in. It was bad luck for him and for the Army, because the age limit prevented him from ever competing again, and in this way he lost all the advantages of the Staff College training and its attendant possibilities. On the other hand, if Ronald had succeeded he would not have been available in the next five years to do for the Corps the work we are about to describe Happily, as the list did not come out until later, his non-success cannot have spoilt Ronald's enjoyment of that wonderful summer, when, we may be sure, he saw the Jubilee and noted the brave show which the Chatham engineers made in Pall Mall. We hope, too, that Ronald and Cedric, horse-lovers both, saw Ormonde beat Minting and Bendigo on Ascot Heath in the great race of the year and of the century.

When Ronald took up home soldiering again in November, 1887, as Commander of "A" Depôt Company at Chatham, he must have become conscious of changes in his twelve years of absence. The side-whiskers, the imperials and the booted overalls had, of course, gone long ago, whilst afternoon tea and lawn-tennis had become necessaries of life ; in London, Northumberland House and its Lion had made way for the Gordon Hotels.

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As regards his own profession, the Home Army, or parts of it, had been almost continuously on active service in South Africa, Egypt and the Sudan.

The Duke of Cambridge, still Commander-in-Chief, had long since moved to Pall Mall, and probably had by now forgotten how much he had disliked the change, while the Inspector-General of Fortifications, Sir Lothian Nicholson, sat in the C.-in-C.'s old room at Whitehall, where for so many years the Duke of Wellington had worked.

Lord Wolseley, in full power with his brilliant following, was Adjutant-General; Sir Redvers Buller was Quartermaster-General, and Colonel Robert Grant, D.A.G.R.E. Much had been done for army efficiency and more was to follow during the coming ten years which Ronald served at home. The Corps and the organization had materially changed. Nine field companies had come into being and the old B (Equipment) Troop had disappeared, although another B (Pontoon) Troop, together with the old A Troop, composed the recently formed Bridging Battalion. C Troop had become the 1st Division of the Telegraph Battalion, and the Post Office Companies formed its second Division. The Submarine Mining Service was at its zenith and its two companies had increased to ten. Chatham he must have found very much the same, except as regards personnel. Colonel Bevan Edwards reigned instead of the genial Commandant of the old days, now a Lieut.-General and Governor of Bermuda, where he delighted his subjects by his skill and agility on the tennis court.

The Adjutant of 1873 was back again at Chatham, drilling the battalion and making it famous for its smartness and efficiency, but now *Colonel* Bruce Brine, *Assistant-Commandant*.

The young officer who in the old days kept a parrot in his room had made a name for himself in Palestine, Egypt and the Sudan, and, as Lieut.-Colonel Kitchener, C.M.G., of the Egyptian Army, was well on the road to fame, but never forgetful of the little cottage under the Sussex Downs where lived his old friend Williams.

In cricket, the ever-green Renny-Tailyour still flourished, and with him and such celebrities as Dumbleton, Friend and Hedley, the Corps had had a very successful season in 1887, losing only one match and beating the Royal Artillery twice. The glamour of the old days had gone from football, and under altered conditions we no longer competed for the Association Cup or made triumphal tours through the North.

When Ronald came to Chatham at the end of 1887, the Service and Depôt Companies still formed one battalion under the Assistant Commandant, but of such a size that it had been found expedient, in July, 1886, to appoint an Assistant Adjutant to help the regular Adjutant with the parade duties on the Square. This Assistant was Cedric Maxwell, who had been commanding a Depôt Company since January of that year. In June, 1889, however, two battalions were formed—a service battalion and a training battalion, each with its own Commander and Adjutant, and Cedric became the first Adjutant of the Training Battalion. He held this post till October, 1889, when Ronald vacated the Command of "A" Depôt Company to succeed Cedric and held the post for two years, till November, 1891, when

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he vacated it on promotion to Major. Ronald then became Major of the Training Battalion for a year, after which he severed his connection with Chatham on succeeding to the command of the 17th Field Company. The "Maxwell" influence at Chatham extended over six years, during three years of which the brothers were there together: it was in this period that the brothers made their great name, and did, perhaps, their best work for the Corps. It seems necessary, at this stage, to consider them together, because they were thought of and spoken of together—those two deeply attached brothers, so like in so many respects—both enthusiastic soldiers, both high-minded, clean-living gentlemen; both good looking, smart, well-dressed and irreproachable in appearance and demeanour, with their outlook on life much the same and their ideas apparently identical. Both were wonderful drills, with resounding words of command; both were strict disciplinarians, held very much in awe by the young officers, but regarded all the same, with unbounded admiration and affection. The Sergt.-Major at Chatham of the time, a man of long experience, regarded Ronald as the greatest disciplinarian he had ever met.

They were both excellent riders and devoted to hunting, on which they usually spent their leave, and many still remember the brown mare Olga on which Ronald won the Tickham Point-to-Point Race.

As the brothers lived in the Mess, the boys saw them off as well as on parade, found them ready to talk and quick to help or give advice to any who appealed for it; many a young officer was put right in little matters of social etiquette in a way that left no feeling of soreness or wounded self-respect. In these circumstances it is no wonder that a Maxwell cult grew up at Chatham, but what does seem remarkable is that after the lapse of a generation memories are still so fresh and gratitude is still so warm—what is here written is an effort to summarize the debt which so many officers of advancing years feel they still owe to the two brothers.

Their reputation spread beyond the limits of Chatham, and when Colonel Bruce Brine, always a warm admirer of the Maxwells, came to Aldershot as C.R.E., in 1888, he used often to tell of the work they were doing, and the writer, at Aldershot at the time, recalls a certain scepticism that two such paladins could be produced who had not graduated in the School of Aldershot.

Whilst both were handsome, Cedric was the taller and perhaps better-looking. "Adonis," he was sometimes called, and more than one lady termed him the handsomest man in the Army. Cedric was almost a dandy and would wear a gayer waistcoat or a brighter tie than the more sober Ronald. Cedric was fair and had a long flowing moustache, Ronald was dark with a short moustache.

Cedric was, perhaps, the more attractive to meet, a little more approachable and with the more engaging manner, for Ronald was always a little metallic, a thin surface of hardness concealing the warm heart and kind nature beneath. Both had the appearance of the soldiers of old days. Cedric might have walked out of the pages of Dumas, whilst Ronald was reminiscent of the Knights of the Holy Sepulchre.

Ronald, as good as Cedric on parade and in the details of soldiering,

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excelled him in office. Ronald had the longer head and perhaps a more tenacious and ambitious nature.

What a pity that Charles Francis was not alive to see them in those days! And how happy the reports of their successes must have made their mother in London!

The stories about the Maxwells at Chatham are endless—how Cedric warned one officer against the ignominy of a made-up tie, and another of the evils of a mourning band in plain clothes.

Two memories of one of the young officers of those times may be given. "One day on parade Ronald was riding a fidgety brown mare (probably Olga, of Point-to-Point fame) that was more at home with hounds than with troops. She was startled by the Band, swerved badly, and Ronald fell off. There was no sign of anger, he just remounted and made an apology to the officers, N.C.O.s and men for his clumsiness, although everyone who saw it knew it was not his fault."

"Another day a discussion took place in the Mess, whether an officer could kneel down in church when dressed in overalls. Ronald quietly remarked that anyone who could not kneel in church because of his overalls must have a rotten bad tailor. We all knew that he said his prayers on his knees and we also knew that he had the best-cut overalls in the station."

The following is from one who commanded a depôt company, when Ronald was Adjutant of the Training Battalion.

"He strove to abolish the idea that the command of a Company at Chatham was a sort of backwater for the inefficient, and instilled the feeling that we all had to take share and responsibility in the training of the recruits and young officers. It was in his time that improvements in the feeding and the cooking of the food for the men were pushed ahead. His guidance and assistance was appreciated by those Company Commanders who were trying to improve the amenities of the Barrack Room in the face of lack of financial help from the War Office."

"The smartness of the companies on parade was almost an innovation, and the recruit squads, when dismissed drill, would have compared favourably with a company of the Guards. To the young officer he seemed, at first, perhaps, overstrict, but they soon found sympathy under a shell of reserve due to natural shyness. But slackness he never condoned, and I remember his quiet sarcasm when an officer tried to excuse himself for being late for parade by saying that his servant had called him too late."

Colonel Champernowne, who commanded the Training Battalion during most of Ronald's time with it, wrote of him: "In this officer is combined, to an unusual degree, great strength and decision of character with tact and gentleness both towards superiors and inferiors."

It is no easy task in regard to anyone to say that here or there he did his best work, but as regards Ronald Maxwell it is difficult to exaggerate the value to the Corps and to the Army of this Chatham period of his, when his influence on those around him was so marked and made so lasting an impression on successive batches of young officers and men at the very outset of their careers.

In November, 1893, Ronald took over command of the 17th Field

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Company, and held it for five years, the last three of which were spent at Aldershot, then under the command of H.R.H. the Duke of Connaught, who had the highest opinion of Maxwell's character and abilities, and who recorded his sense of the value of Maxwell's services at the New Forest manœuvres of 1895. Those who laboured in the same field will feel it is doing them no injustice to say that in Ronald Maxwell's day the 17th Field Company was second to none in efficiency. One of the subalterns of these times writes: "We had a most tremendous admiration for the Major, and were very proud of belonging to the 17th Field Company and considered our unit streets ahead of every other, owing to the Major's thoroughness in everything."

Another subaltern writes: "At that time he really seemed to have no other interest in life except his Company and hunting, and lived for and thought of nothing else. It is not, therefore, surprising that he acquired the knowledge of the men of the Corps which enabled him afterwards to do such valuable work for it."

Ronald, mounted on his black thoroughbred mare Serenade, attended the Diamond Jubilee in 1897, with a detachment of the 17th Field Company as part of the Aldershot R.E. Contingent which helped to line the route of the procession.

Serenade, however, on this occasion very nearly let her rider down. Tired and very hungry after the long wait, she stretched out as the Queen's carriage passed by and all but secured for her mid-day feed the feathers in the Royal bonnet.

Ronald Maxwell came to the top of the foreign service roster for Majors in November, 1897, and after ten years' Home service embarked once more for India. On arrival he was posted to the ordinary work of the Corps as Garrison Engineer at Mian Meer, and stayed there for five months, not finding India much changed during his twelve years' absence. In May, 1898, on the D.A.A.G. for R.E. going home on a year's leave, Maxwell, fresh from home with up-to-date knowledge, was specially put in to officiate in his place at Simla. He nearly came in for a campaign against the Mad Mullah and had been appointed C.R.E. to the Force which was to take the field when, fortunately or unfortunately, the Mullah submitted.

Whilst at Simla, Maxwell acted as Secretary to the Indian Defence Committee, and he has described in graphic terms a visit to Burmah, to be present at the rehearsal of the Rangoon Defence Scheme, and how one night, on a river steamer, a Burmese thief found his way into his cabin and carried off his dispatch-box with 500 rupees inside it.

In April, 1899, when his time as officiating D.A.A.G. was over, he was posted to Calcutta as Garrison Engineer, but four months later, on returning after a tour of inspection in Assam, he found a telegram awaiting him asking him if he would accept the command of the Training Battalion at Chatham. He hastily replied "Yes," and on the 19th August sailed for home after but a year and nine months in India. The propriety of bringing an officer home from India after so short a time was questioned in Parliament, and the reply was that a special officer was required for so important a post and that Maxwell was the most suitable.

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When Maxwell took over his duties at Chatham on the 5th of September, the Boer War was within five weeks of breaking out, and the next three months after the die was cast must have been very busy ones for the Training Battalion Commander, with the call for men to fill up the new units that were being formed. Maxwell, however, was not destined for a long stay at Chatham. On the receipt of the news of the Battle of Colenso orders were issued on December 16th to mobilize the 7th Division and Maxwell was appointed its C.R.E., the Divisional General being Lieut.-General Charles Tucker. No time was lost, and on the 4th January Maxwell embarked for South Africa.

At the farewell dinner given at Chatham, the Commandant, Sir Thomas Fraser, said in his speech that, it being decided to have the very best man to command the Training Battalion, the War Office, against great opposition and contrary to all precedent, had succeeded in prevailing on the Government of India to curtail Maxwell's tour of service in that country in order that he might take up a command for which he was pre-eminently fitted.

At that time it was expected that the South African campaign would be over in six months, and so Maxwell left his quarters in Chatham all standing, with the intention of returning to complete his term of command. But this was not to be, and after a considerable time he was gazetted out of the Training Battalion and replaced.

Reaching Capetown on the 25th January, 1900, the Division was dispatched through De Aar to Orange River Station, where it formed part of the force being assembled between the Orange River and the Modder. Here during the next fortnight we find Maxwell and the Engineers of the 7th Division devising and preparing elaborate water supply arrangements for the force.

C.R.E.'s of Divisions had not a comfortable billet in South Africa: not being on the Staff they had to live with their single field company, and the result was not always happy, especially when the C.R.E. was unusually keen: fortunately in their case Maxwell and the Company Commander were old comrades and friends, not very far separated in seniority.

When the battle of Paardeburg was being fought the 7th Division was at Jacobsdal and, leaving that place at 9 p.m. on the evening of the battle (February 18th), it made a forced march and arrived on the field at 3 p.m. on the following day. On the next night (20th) the Engineers of the Division and its 14th Brigade, under Sir Herbert Chermside, moved eastward to prosecute the close attack of the Boer laager from that side on both banks of the river.

This work was executed under Maxwell's direction, and is described as follows in the Official History of the War: "Every evening before sunset Lieut.-Colonel R. C. Maxwell, C.R.E. 7th Division, and his Staff reconnoitred to the front, and were thus able to give precise orders for the capture during the night of sites which, under the protection of covering parties, were entrenched before sunrise and by the time Paardeburg fell (February 27th) Maxwell's trenches were within 250 yards of the nearest Boer trenches."

Sir Elliot Wood, who was Engineer-in-Chief of the Force, in his

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interesting book, entitled *Life and Adventures in Peace and War*, is referring to this period when he says: "Above the Boer laager Chermside's Engineer Officers were daring, Colonel Maxwell reconnoitring alone down the river bank daily 200 to 300 yards in advance of the last trench and blazing trees to mark the fresh night's trench work. The enemy sniped all day from cleverly concealed trenches."

Maxwell accompanied the Division on the march to Bloemfontein, and was present at the actions of Poplar Grove, Karee Siding, Vet River and Zand River. He fell sick at Kroonstadt during the march to Pretoria, and was absent for a few weeks before he rejoined the Division at Pretoria.

When the Division was broken up and the Column fighting began, Maxwell became C.R.E. Pretoria District, January 1st, 1901, and remained at Pretoria for another year and a half, when he returned home on the conclusion of peace in June 22nd, 1902.

During his two years at Pretoria, Maxwell toiled incessantly at his job; the work to be done was unending—sanitation, hospitals, defences, not to mention a factory for the construction of the Rice pattern corrugated iron block house, which did so much to end the war.

For the great bulk of the work civil labour had to be used. Italian masons and other European artisans collected on the Rand and hundreds of native labourers; contractors had to be found and used—some good and some very bad. All this work was immensely useful and valuable, but it must have been very trying to Maxwell's ambitious spirit to see the columns coming into and going out of Pretoria commanded by officers mostly junior to himself, and not a bit more qualified, whilst he remained to make huts, latrines and defences round the town. Cedric, although desperately ill, commanded a column for the early days, and he rode and fought until he dropped—dead. We last hear of him as visiting Ronald at Pretoria, "a very nice-looking fair-haired man with a pointed golden beard, but looking so delicate."

Maxwell's assistant at this time, himself desperately anxious to fight, and tired of signing C.R.E.'s orders, which Maxwell wrote with his own pen, asked him why he never applied for a Column, and the reply was that he did not think it right to ask for things. We may regret the reply, but if he had asked, it would not have been the Maxwell we have come to know. His superiors should have pressed his claims for the fighting work for which he was so pre-eminently suited, but we presume they found him too useful and did not like to give him up. His generals all admired him and his work, and Sir Charles Tucker, in a most appreciative letter, writes of him as "a man in a thousand," whilst General Barton, for long in command of the Pretoria District, reported on him in the very highest terms. That Maxwell's services were appreciated is shown by his mention in dispatches and by the award of the C.B.

On arrival home Maxwell took over, on July 1st, 1902, the duties of A.A.G.R.E., the appointment of D.A.G.R.E., having been reduced to the lower grade when Sir William Salmond's tenure of office expired.

We now come to Ronald's romance. In 1889 he met Miss Burnaby Atkins at a Chatham ball, and ten years later, on his return from India, they met again at Rochester, and saw something of one another, until

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she was summoned home and he was sent to South Africa. They had fallen in love with one another and, three years later, on his return home, they were married after a seven weeks' engagement on February 3rd, 1903. Never was there a happier marriage, not even that one at Malta sixty-four years before—one had only to meet them to know their radiant happiness, and to realize what a prize each had secured. It was good for Ronald to have someone to tell him how delightful he was; it broke through his diffidence and dissipated much of the impenetrable reserve so characteristic of his middle years.

At the War Office, Maxwell found Lord Roberts Commander-in-Chief with Sir Thomas Kelly Kenny, the Adjutant-General, as his immediate chief. Sir Richard Harrison was I.G.F., to be followed nine months later by Major-General W. T. Shone, C.B.

This state did not last long, for on February 12th, 1904, as a result of the Report of the Esher Committee, all the high officers disappeared and the War Office found itself reorganized. Maxwell now came under a new Adjutant-General, Sir Charles Douglas, whilst the work he formerly transacted with the I.G.F. he now did partly with the Director of Fortifications and Works and partly with the Inspector of Royal Engineers. In his new chief Maxwell soon found a friend and staunch supporter. The two men had many qualities in common; the same industry, the same knowledge and love of detail and to Sir Charles' appreciation Maxwell owed a great deal in the coming years.

It is hard to give any connected account of Maxwell's work as A.A.G., but, as may be expected, he put his shoulder to the wheel and worked long hours. To visitors he was always courteous, if not very expansive, and it was opposed to his view of things for officers to come and ask to be sent here or there; he would not have done it himself and did not altogether approve of other people doing it. There was immense confidence, however, in his justice, and fair play, and on occasions certainly he was out to help volunteers. One officer, now in high position, who had served under him in South Africa wrote and asked him to help him to Somaliland. Maxwell never answered the letter or referred to it afterwards, but the officer went where he wanted, and by a pure accident discovered afterwards how much trouble Maxwell had taken to bring about the result.

The D.F.W. of those days, Major-General Sir R. M. Ruck, has recorded his gratitude for the support and assistance he received from Maxwell, and how the latter backed him when, shortly after the new dispensation came into being, proposals were started to withdraw Engineer pay in order to increase the emoluments of the Cavalry. The Secretary of State supported Ruck, and as a result a committee, under Sir Evelyn Wood, was appointed to reconsider the duties of the Corps.

The report effectually safeguarded the legitimate interests of the Corps, and made a number of valuable proposals which were afterwards carried into effect, such as the provision of a Second Field Company for each Division and the organization of an R.E. Reserve of Officers, obtained with the assistance of the Institution of Civil Engineers.

At this period was sounded the death-knell of the Submarine Mining Service, involving considerable reductions in the Corps and a great deal

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of reorganization in arranging for the electric lighting duties to be carried out in fortresses. All this meant work for Maxwell.

At the conclusion of his four years at the War Office and after an interval of ten days' half pay, Maxwell went to the Western Command as Brigadier-General in charge of Administration, a post he held for three years and three months, and which he vacated on promotion, three months after he became a Major-General on July 28th, 1909.

His General for the first nine months was Sir Francis Howard, and for the subsequent period Sir Charles Burnett, and both Generals found in Maxwell a tower of strength, and said so in their reports. They could go to sleep at night with the feeling that if anything went wrong in the Command it certainly would *not* be in the services which Maxwell controlled.

He was a great worker, and astonished the Administrative and Departmental Staff at Chester with the hours he kept and sometimes made them keep.

One writes: "I was very fond of Ronald Maxwell, and got on very well with him—he was a tremendous worker, with a great head for detail, and a most charming gentleman; rather too fond of doing everything himself and sitting late in the office, but notwithstanding this we all loved him, as he was straight as a die and was always very appreciative of the efforts of his subordinates."

While Maxwell was at Chester, the Territorial Scheme came into being, and, with three Divisions allotted to the Command, the task of organization was enormous and the bulk of it fell on Maxwell's shoulders.

It was at this period that he learned to speak so well in public, because his General used often to send him to represent him at functions where speech-making was required. He thus became an excellent speaker, and on the writer complimenting him about it Maxwell gave the above as an explanation.

Whilst at Chester, the Maxwells lived at Eccleston, in a little house called Riverside, on the Dee: his wife shared Maxwell's great delight in horses, and we hear of a pair of dark chestnuts at Chester that took the Maxwells on many a trip.

After leaving the Western Command, Maxwell had only 44 days' half pay before he took over the duties of Major-General in charge of Administration, Southern Command, on December 11th, 1909, where he found his former chief, Sir Charles Douglas, as G.O.C.-in-C.

The Administration of the Southern Command was in many respects a larger problem than that of the Western Command. There were many more regular troops to deal with, both on Salisbury Plain and in the two fortresses of Portsmouth and Plymouth, whilst there were unlimited camps and manœuvre arrangements in the summer. His administrative work at the manœuvres of 1910 came in for very high commendation, and marked him out as eminently fitted for such work in time of war.

If the office hours were long at Chester, they were longer still at Salisbury; he was in the office nearly twelve hours a day, and his home saw little of him during these two years. But, if Sir Charles Douglas was a task-master, he had the highest opinion of Maxwell's administrative

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merits, describing him as the best administrative staff officer he had ever met, and recommending him confidently as fitted for the post of Quarter-master-General.

Whilst at Salisbury, the Maxwells lived in a charming old house, The Moat, at Britford, where by the running water of the moat the kingfishers used to build. At Longford Castle, hard by, Ronald must have been interested to see again the pictures that used to hang in the dining-room at Delapré Abbey in his schoolboy days, of his beautiful great-grandmother, painted by Reynolds, of the "Uncle Harry" of happy Malta days, and of "Cousin Everard," who had been so good a friend to two generations of Maxwells.

Maxwell remained at Salisbury for just two years, when he was transferred to the Command of the Eastern Coast Defences at Chatham on December 17th, 1911.

After the labours of Salisbury, Maxwell must have been glad to get a Command of his own, and at a place which he knew so well, and here he served for two years and eight months, until the first month of the Great War. The Chatham time was the happiest of all for the Maxwells. Ronald did not have to work so hard, and even took to playing golf in the afternoons with his A.D.C. They still had horses and spare hours in which to ride them. The nice old General's Quarters in Chatham Barracks, with its large walled garden, was ideal for entertaining; Ronald liked gathering there his soldier, sailor and civilian friends, and his wife felt that for the first time she was having a share in his work.

His most important official task at Chatham seems to have been the preparation of the Defence Scheme. In a paper which he has left behind is stated: "It took me and my Staff two years to work out all the details for the Eastern Coast Defences, to choose the positions to be held, to design the works to be executed, to make a detailed distribution of the troops placed at disposal on mobilization, and to arrange beforehand all questions of transport and supply, in addition to planning the hutting to be executed."

It is not often that such preparations are destined to be put to an early test, but in this case Maxwell and his Staff had their reward, for when mobilization came in August, 1914, and all the outside troops allotted to the defences arrived, everything was in order and the whole complicated machine worked without a hitch.

In the winter of 1911–12 the Maxwells went on leave to Freiburg, in South Germany, where at one time the Maxwell family had resided, and Ronald paid a visit to the G.O.C. of the Baden Corps. They had a long and agreeable conversation in German about the relations between England and Germany; when bidding the Baden General good-bye, Maxwell told him he was in command of the Eastern Coast Defences, and said, "If you ever come to England, I shall be the first to welcome you, whether you come in peace or war." On the German replying that he would come in war, Maxwell asked him why, and the reply was that there must be war, and that England and Germany would have to be on opposite sides, as they were the two most powerful nations, and were competitors for the trade of the world.

Sir James Grierson was Maxwell's G.O.C.-in-C. during his time at

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Chatham, and highly appreciated his work at Staff rides and elsewhere, and believed in him as having all the knowledge and qualities for a Command in the Field.

In the interludes of preparing the defence scheme we may be sure that Ronald kept a watchful eye on the well-being and efficiency of his Command, and not least of his own Corps.

One who was then commanding the Training Battalion writes: "One always felt how much he appreciated our efforts to attain to those high ideals which he himself had done so much to inculcate when in the Corps."

We owe to the same source the following humorous and characteristic account of an incident which occurred at the mobilization in 1914.

"In those days the Training Battalion became an emergency battalion on mobilization for the defence of the Chattenden magazines, an emergency which actually materialized, although I do not think many of us appreciated how soon our make-believe mobilization would be practically tested. Anyway, the General was under no illusions in the matter, and one very hot summer's day I, as O.C. Emergency Battalion, was directed to report to his office; when I was ushered in, he was in his chair, beautifully turned out, cool, calm and collected, with a new row of ribbons on his chest. Although he was always particularly courteous, I was painfully aware that I had no ribbons on and that my buttons had not been properly cleaned since early morning parade. A huge map of the magazines was in front of the General, and behind him stood the Chief Engineer.

"I was requested to give my views of the defence. A discussion arose as to a particular site, and down came the Chief Engineer's finger in clammy haste over the General's shoulder on to the beautiful map. The General silently applied his forefinger and thumb to the offending finger and removed it to one side, and the Chief Engineer gave me a look.

"The discussion was resumed; after some little time we again became lost in argument, and once more the Chief Engineer's finger descended swiftly to imprint itself on the map. Exactly the same procedure was adopted, and the General courteously but firmly, with no word spoken, once more removed the finger. This time the Chief Engineer looked at me and winked, but the incident was not repeated."

At the end of August, 1914, Lord Kitchener sent for Maxwell to the War Office, where everybody was busy over the raising of the first of the New Armies. Here, with the title of Assistant to the Chief of the General Staff, Maxwell was for three weeks employed in supervising how the work of expansion was proceeding; he had to go to Lord Kitchener every morning to tell him how things were going on. Lord Kitchener wanted to know which department was getting behindhand and required driving; one day the difficulty was tents or hutments, another day big guns, another day rifles or ammunition, another day probably horses or saddlery and so on.

On September 19th, 1914, Lord Kitchener, after having received Maxwell's morning report, told him that he was going to be sent as Inspector-General of Communications to France, and that the sooner he started the better. Maxwell replied, "I will cross to-night." He had

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some trouble in collecting his kit, which was half at Chatham and half in London, but he got away that evening and crossed to France by the boat from Southampton to Havre.

When Maxwell crossed to France he was within five months of being 62, and of being compulsorily retired at that age. He had been unfortunate in never getting any brevet promotion, with the result that when he became a general officer he was considerably older than most men of his rank. In August, 1914, of the 50 Generals above him on the list, only six were older than he, and of those not one served in France; throughout the war Maxwell was working alongside of men many years younger than he. When he became I.G.C. the only officer in France his senior in age, and that only by three months, was Sir John French, and when the Command changed fifteen months later, Maxwell became much the oldest senior officer in France; he had as his chief one nine years younger, whilst the Army Commanders and his colleagues at G.H.Q. averaged ten years less than he in age.

These facts are mentioned because, without them, the full merit of Maxwell's achievement is missed; they help us also to understand how young he must have been and was for his years; no one meeting him casually would have put him down at anything like his actual age.

Maxwell, with the temporary rank of Lieut.-General, took over the charge of the Communications in France at a very difficult moment. It had become necessary to transfer our bases at Calais, Boulogne and Havre to Nantes and St. Nazaire on the Loire, and in the necessarily hurried move there was inevitable confusion. This had to be put straight and hardly had that been done when early in October the former bases had to be resumed. The Indian Contingent and other Divisions were shortly due to arrive, and order had to be evolved from something not far removed from chaos.

On arrival, he made a hurried visit to G.H.Q., at Fère-en-Tardenois, to receive instructions, and then went back to the H.Q.L. of C. near Paris, where he took over the duties on September 22nd.

Maxwell tackled the job with his customary energy and self-denial. He neither spared himself nor others, and the order of the day was usually, office from 8 a.m. to midnight, and sometimes later, with the shortest of breaks for meals and 1 to 1½ hours in the afternoon invariably set aside for walking or riding exercises.

The H.Q.L. of C. were moved to Abbeville on October 15th, by which time it may be said that the L. of C. was an organized concern.

During the four months he was I.G.C., Maxwell worked in the closest touch with and the most willing subordination to the Q.M.G. in France, Sir William Robertson, who found Maxwell a great help and ready to modify the organization contemplated by the pre-war regulations to what actuality seemed to require.

Maxwell was I.G.C. sufficiently long to be able to place the organization of the L. of C. on a sound basis designed to meet the inevitable expansion of the Army from 6 to 60 Divisions. A Staff Officer writes:—

"I would assess his achievement in founding the organization of the L. of C., as he did, as almost the most successful of his efforts. The task suited him in every way. It required very thorough, painstaking, careful,

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really hard work. No detail could be overlooked, for the omission of a detail might have weakened the whole fabric. General Maxwell got down to it all and plodded away at it ceaselessly; and steadily, step by step, he built it up; every piece was examined carefully, then fitted in firmly and truly in its proper place at the right time. His work was always systematic, it was not improvisation, it was always solid organization."

At the end of January, 1915, Sir William Robertson became C.G.S. to Lord French, and on his recommendation, Maxwell, who was rewarded for his work on the L. of C. by being created a K.C.B., on 18th February, 1915, became Quartermaster-General in France on January 27th, 1915. When Maxwell joined General Headquarters, they were at Saint Omer, where they remained until 31st March, 1916, when they were moved to Montreuil.

For the first eleven months of his time as Q.M.G., Lord French was Maxwell's chief, until he was succeeded by Sir Douglas Haig on 19th December, 1915.

Of Maxwell Lord Ypres writes :—" Maxwell served with me in France, first as I.G.C., and then as Q.M.G. I found him excellent in both capacities. He rendered most valuable service to the forces in the Field, and I shall always hold his memory in the deepest gratitude for the help he gave me. He is a great loss to the service."

In sending the above to the compiler of this Memoir, the Field-Marshal adds, " I write as I do from my heart, and am truly glad to have such an opportunity of testifying to the fine qualities and character of a comrade I greatly regard, and whose loss I mourn."

Officers of the Corps will value this tribute, coming from one who, to the writer's knowledge, extending over many years, has always been a warm supporter of the Corps and an appreciative admirer of its good and gallant service in the field.

Sir William Robertson, in writing of the 11 months when he was C.G.S. and Maxwell was Q.M.G., tells us that, having found Maxwell a great help as I.G.C., he now found him equally helpful as Q.M.G. to the C.G.S., and to the whole of the General Staff side of G.H.Q. At this period, although the Army at the Front was comparatively small, the Q.M.G. work was in many ways more difficult than subsequently; everything was new and different from what had been expected, and there were a thousand and one matters to be settled in conjunction with the French authorities which had never been thought of before. In those days, too, resources were deficient and, in consequence, the arrangements to be made were far more onerous and complicated than later on, when resources were plentiful. In the words of one of Maxwell's staff :—

" In his new appointment his work covered a wider field, although in its nature it was in many respects similar to what he had been doing as I.G.C. His activities were directed in the main to constructive organization, though, of course, he became more closely associated in the general administration of the Force, and in the higher direction of the operations in the Field. His experience as I.G.C. was invaluable to him, and his knowledge of the L. of C. enabled him to concentrate more time and attention on the forward services for which he was responsible." His successor as I.G.C., Sir T. F. Clayton, in a striking tribute to the high

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character of Maxwell's work, and to the affection which he inspired, tells us how harmonious were their relations, and what support and ungrudging help he always received from Maxwell.

During Maxwell's service as Q.M.G. the Army in France was constantly expanding, and reached its maximum number just before he came home; and when the Armistice was signed, there had been a fall of 4212 in the total numbers in France.

The ration strength when Maxwell first landed in France was 101,486; it had risen to 332,082 when he became Q.M.G., and when his tenure of office came to an end, the number was 1,970,939, a total expansion of 1,869,453.

In other words, when Maxwell left France, the Army was 18 times greater than when he went there, whilst during his period as Q.M.G. the forces had increased considerably over fivefold in strength.

The reader will appreciate the immense expansion of administrative arrangements required to meet the increase and that this work of expansion was completed before Maxwell's hand had been removed from the plough.

As the size of the Force developed, and especially on the advent of large numbers of the New Divisions, transportation difficulties developed in the British zone.

It was necessary to expand the railway system, to make greater use of inland water transport, and to insure against undue congestion at the ports. To meet the situation, it was decided in the autumn of 1916 to reorganize the transportation services and to place the complete control of the whole in the hands of a Director-General of Transportation, with direct access to the Commander-in-Chief. This involved far-reaching administrative changes; the Q.M.G. lost his control of transportation services, whilst the office of I.G.C. came to an end, his transportation work going to the D.G.T. and his administrative services to the Q.M.G.; for the I.G.C. was substituted a G.O.C. L. of C. Area, in command of L. of C. troops, reinforcement depôts and base camps.

Maxwell was not at first in favour of the revolution effected, but, once the change was determined on, he laid himself out characteristically to do everything to make the new system work smoothly.

A large number of officers in the new organization were civilian specialists, given temporary Army rank, and necessarily without much knowledge of Army administration, and the transfer to them of the many transportation responsibilities could only be satisfactorily effected by their being given the utmost assistance by the senior officers of the B.E.F., and especially by the Q.M.G. The D.G.T., Sir Eric Geddes, appreciated this help from the beginning, and in his first progress report to 31st December, 1916, he wrote as follows: "I would like to acknowledge with gratitude the never-failing assistance and co-operation of the Q.M.G., not only in effecting the transfer, but in ensuring as far as could be the smooth working of the new organization. If, as I believe, it has been introduced without dislocation or friction, it is largely due to the Q.M.G.'s personal assistance."

These happy relations, so creditable to both, continued, and when Sir Eric Geddes left France, in May, 1917, for even more important

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work at home, he wrote Maxwell a letter showing the warmest appreciation of the assistance received.

The staff of the Q.M.G. grew as the Force increased, and with the continued tendency to concentrate at G.H.Q. decisions in regard to administrative questions.

In October, 1917, Maxwell had two D.Q.M.G.'s under him, one dealing with movements and ammunition supply, and one for other questions; there were 4 A.Q.M.G.'s, 5 D.A.Q.M.G.'s, 5 Staff Captains, and an unascertained quantity of clerks and typewriters.

The above is quite apart from the various directors under the Q.M.G.; the Directors of Supply, Transport, Ordnance Services, Remounts, Army Veterinary Department, Postal Services, and Works. These all had to come to the Q.M.G. when any important decision had to be made. In addition to the Services implied in the above we have to remember requisitions, billets, claims, labour, salvage, agriculture, forestry and canteens, whilst up to December, 1916, Maxwell also had on his shoulders railway and inland water transport.

The enumeration of the preceding enables the reader to judge that Maxwell's day was a full one, especially when we remember how thorough he was and how determined to know about everything and to be certain that the best that could be done was carried out. The wonder is that he was able to stand the strain in the way he did.

He used to have a long day, breakfasting early, about 7.45, and then to the office all day and for much of the night, too.

One of his staff writes: "The forenoon was usually taken up to a considerable extent with visits to and from the C.G.S., A.G., and other Senior Staff Officers, and an occasional interview with the Commander-in-Chief. Then followed an almost continual seeing of papers with his staff, and the various Directors of the administrative Services and Departments. For a time he held an evening conference at 9.30 p.m., attended by representatives of each branch of his staff and by representatives of the larger directorates. When G.H.Q. increased in size and new services and departments were formed, the evening conferences lapsed, and though there were frequent meetings of those concerned in his office, daily conferences at a fixed hour were discontinued. Full-dress conferences were convened, when there were any very special developments. At all such meetings over which he presided Sir Ronald's intimate knowledge of the detailed work of each department was very noticeable. No matter how strenuous his day might be, immediately after dinner he walked briskly back to his office to tackle 3 or 4 hours' more work as keen as if he were beginning the day. On returning to G.H.Q. after a long day of inspection or being at a conference, it was just the same, he never showed signs of real fatigue. When men, 20 and 30 years younger than he, were beginning to flag and to display weariness, he would be full of vigour. His perseverance and determination were immense."

Space does not permit us to give at length the vivid descriptions available of how he interviewed his staff, always making them sit in front of him, and never behind or alongside; of the ordeals these visits sometimes were, but how calm, kind, and unruffled Maxwell always was.

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Another writes: "To take papers to Q., to answer in person the written order 'Speak,' was, undoubtedly, not only to newcomers, something of an ordeal. With him, as in the case of Charles Lamb's *têtes-a-tête*, there could be no shuffling. The points of a case, and the previous correspondence connected with it, had to be mastered from A to Z, and if the superficial and bustling critic thought his methods were old-fashioned and that he could not see the wood for the trees, a closer acquaintance proved that here was a man whose amazing knowledge of detail had not dimmed his perception of broad issues or clouded his capacity for initiating and guiding the main lines of policy."

One of his directors writes: "My work brought me into daily association with him, and a more courteous chief and better type of English gentleman I have never met. With all his heavy responsibilities and the mass of work which fell on his shoulders, he was always accessible, and I cannot recall ever seeing him out of temper, impatient or petulant, and there were many happenings in those days with the British Army in France which were enough to upset the outward equanimity of the chief administrator of our Army."

Another director writes: "All I know about my old chief is that he was the whitest man I ever had the honour of serving under; even in the most trying times he never lost his temper, was always sympathetic with his subordinates, and would fight to the last ditch in their defence if he thought they had done their best."

The daily routine was happily varied by visits of inspection to the Front or attendance at conferences.

One we have already quoted writes: "He loved the French language, and was very proud of his proficiency in it. He was possibly seen at his very best when taking part in a conference at the French G.Q.G.; and conferences and discussions with the French undoubtedly gave him great enjoyment. Master of every detail of the subject under discussion, understanding and sympathizing with the severely accurate French staff methods, he seemed to revel in it all. At the end of possibly hours of excited and valuable discussion, when other British officers were obviously jaded and weary, Maxwell emerged from the meeting, looking as if he had had the most pleasant hour of life. His courteous old-world manner, his dignified and soldierly bearing, his smart and well-groomed appearance, and his punctilious attention to the French military etiquette, appealed immensely to the French, and their confidence in him was great."

His knowledge of German also came out, and on one occasion when inspecting German prisoners who were making charcoal in a forest near Rouen, he astonished the N.C.O. in charge by his knowledge of the technical terms of the industry in the prisoners' language.

Maxwell's usual daily recreation at G.H.Q. was a walk on the ramparts, or more frequently a ride for a couple of hours. It was on one of these rides, September 14th, 1916, that he had a serious accident; his horse bolted with him, gave him a bad fall and a broken wrist. This necessitated his being on the sick list for a short time; with this exception Maxwell never missed an hour's work on account of illness, or of being in the doctor's hands, during the whole time he was in France. This

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incident is mentioned because an obituary notice in the *Times* said that it was this fall which caused Maxwell to return to England in 1917.

This statement was quite incorrect. Maxwell carried on for 15 months after the accident, and when the writer visited Montreuil in December, 1916, Maxwell was perfectly well, and the accident was so little regarded that the writer never even heard it mentioned.

In his life of hard work at G.H.Q. there was another side which Maxwell thoroughly enjoyed, keeping open house and entertaining a very large number of people, civil as well as military.

Maxwell, with some of his staff, was fortunate enough to occupy a fine old house filled with beautiful things, and possessing a large garden.

One of his staff writes: "I can hardly remember a meal except breakfast when we did not have guests. From His Majesty the King and the Prince of Wales downwards, the list included Archbishops, Ministers, Diplomats, Generals, English, French, and American, as well as endless people who came out from England on different missions and inquiries"; the writer, who falls under the latter category, gratefully remembers the genial atmosphere, and how completely Maxwell threw aside his work to make his guests feel at home. The same staff officer writes: "General Maxwell loved hospitality, but also had an end in view, which was to create a genial atmosphere, so as to overcome any difficulties that might crop up or had cropped up in the many and various departments under him or with the French." We quote once more from the same pen: "No one ever asked advice of him in vain, and the way in which it was given was always kind and friendly. It was so with me, and it generally began 'Well, if I were you, I should do so and so.' I never heard him grumble or say an unkind word of anybody; he never thought of himself; only of what was best, or thought best, for the carrying on of the War and the ultimate good of his country."

In December, 1917, Maxwell learnt that the War Office considered that the time had come to relieve him by a younger man, and in due course an official communication arrived from the Army Council to the effect that, while they were fully sensible of the excellent work performed by him during the past three years, they considered that, having regard to the requirements of the future, the time had come to replace him by a younger man. The Field-Marshal commanding was requested to convey to Maxwell the Council's thanks for his valuable services and unsparing devotion to duty, first as I.G.C. and subsequently as Q.M.G., in the very arduous conditions which obtained throughout the whole period of his service in France. In transmitting the above decision to Maxwell the C.-in-C. wrote: "I wish to express my high appreciation of the services rendered by you during the two years you have served under me as Q.M.G. The constantly increasing work and the large expansion of your department have been carried through without loss of efficiency, and the many difficulties you have had to contend with have been surmounted smoothly and without failure on any occasion. You will have the satisfaction of knowing that you are leaving your department in a most efficient state. I thank you most sincerely for the valuable assistance which you have given me at all times."

And so it came about that on the 23rd December, 1917, Maxwell's

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active service ended, and he came home on half-pay at the close of 3 years and 3 months' service in France, during which he had devised and carried out great administrative developments and had earned for himself a high and enduring place among those who had a predominating share in carrying through to a successful conclusion the greatest struggle in which the Country has ever been engaged.

He was made a K.C.M.G. within a week of his return home, and in the Commander-in-Chief's dispatch of the 21st March, 1919, we read: "During 1916 and 1917 the duties of the Q.M.G.'s branch were ably directed during a period of constant expansion by Lieut.-General Sir Ronald Maxwell."

He had already been promoted to the rank of Lieut.-General on October 6th, 1916, whilst his services with France and Belgium were recognized by his appointment as Grand Officer both of the Legion of Honour and of the Order of the Crown of Belgium.

He left behind him in France a staff which regretted his departure and who have furnished the writer with the most striking tributes of their affection for the man, their confidence in his work, and their respect for and admiration of his abilities. Many of them, and others, had a natural pang of regret that Maxwell was not left to complete the work which he had commenced, but we have to remember that in December, 1917, the likelihood was that the War would last much longer than it eventually did; no man can stand a continuous and heavy strain indefinitely, and the Government doubtless felt that it was better to make the change when all was well rather than run the possibility of having to do so later when powers began to fail and when national disadvantage might be the result.

That Maxwell was able to direct with undiminished power the vast machine which he had devised up to the age of 65 seems an astounding physical, mental and moral achievement.

To his successor was left the task of controlling a system received in full working order, and it seems that the general lines which Maxwell had laid down were carried on unchanged until the conclusion of hostilities.

Shortly after the return from France, the Maxwells purchased The Old House at Singleton, below the Sussex Downs, and spent a great deal of their time laying out the garden and in improving the quaint and attractive house. Here we find Ronald running the Boy Scouts and doing what he could for the well-being of the little community, and it is from notes from lectures given at social centres that we have culled some of the incidents of his earlier days. He returned to the amateur stage as "King Valoroso" in Thackeray's "Rose and the Ring," and as the "Dream Maker" in the fantasy by Oliphant Down, called "A Maker of Dreams," whilst a photograph shows the ex-Quarter-Master-General dressed as a Sussex wagoner at the Singleton celebrations of that peace which Ronald had done so much to bring about.

At the conclusion of the War, Maxwell was made Chairman of the Committee which dealt with the R.E. War Memorial, and those associated with him in the work bear witness to the interest he exhibited, to his broadness of view and to the tact which guided the members to an agreed course of action.

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Maxwell also took an active part in the work of the R.E. Old Comrades' Association: he became a Vice-President in 1920, and presided at the annual dinners in 1921, 1922, and 1923, and in the latter year was elected President, on General Sir Richard Harrison's finding it necessary to relinquish the post.

One of the last duties which Maxwell performed was to see the Secretary of the Association in regard to the Memorial Service to the late Sir George Scott-Moncrieff. Maxwell was then in a nursing home in London, and obviously very ill indeed, but the Secretary tells us how calm he was, how keen was his interest in the matter in hand, and how many were the questions he asked relating to the Corps and to those connected with it.

In the autumn of 1921, finding themselves in Sussex rather too far away from relations and friends, the Maxwells sold "The Old House," and in the following spring moved into Poplars, Burghfield Common, near Reading. Here they were within easy reach of brothers Nigel and Aymer, both living in Oxfordshire, whilst at Ewelme, not so far away, were Ronald's two unmarried sisters, who had settled there after their mother's death.

Ronald took the greatest interest in making the new house nice and in turning a paddock into a croquet lawn, where he played throughout the summer of 1923. There seemed more scope for him at his new home, where he was on the Rural District Council and the Board of Guardians, as well as a member of the Parochial Church Council and Chairman of the British Legion. Not very far from Newbury, he belonged to the Race Club there, and enjoyed the meetings in frequent company with his two brothers.

In these congenial circumstances, a number of happy years seemed in front of the Maxwells, but in the spring of this year (1924), Ronald began to fail, and, although everything possible was done, he gradually just faded out of existence.

He was characteristically brave and patient in his increasing weakness, and to within a week of the end used to insist on being carried out to the garden, where he could enjoy the roses he had pruned and the flowers which he and his wife had planted together.

He died peacefully on July 20th, after a few hours of unconsciousness, and to quote his wife's words, "on that last Sunday morning, as we were watching him, he put his arms down to his sides in the attitude of 'attention,' and I shall always believe he passed into the presence of the Greatest Commander-in-Chief and heard the word 'well done.'"

The funeral, simple and of a non-military character, took place at Ewelme on Wednesday, July 23rd, and after a service in the attractive old church, with its beautiful memorial to Cedric, the body of Ronald Maxwell was laid to rest in the sloping high ground above the church.

H.M.L.

*November 5th*, 1924.

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## *SURVEY NOTES.*

A COLONIAL Survey Section, Royal Engineers, under the command of Capt. S. W. Kirby, M.C., R.E., is now working in Johore. This survey is of peculiar interest, because it is in close touch with the hydrographic work now being carried out by H.M. Surveying Ship *Iroquois*, and depends to some extent upon the photography carried out by a unit of seaplanes. The employment of photography from the air along the coasts and rivers and covering the cleared areas of Johore is extremely interesting from a survey point of view, and promises to be most useful. Capt. Kirby is not the first surveyor to be carried about with his instruments from one point to another, but he is sufficiently nearly so to provide a striking illustration of the help which aircraft may render to a survey not only in photography but in transport over very difficult country. With these novel duties superimposed on the adventures of working in tropical forest, Capt. Kirby is to be congratulated on the interest of his job.

Air photographs will presently be taken of Hong Kong, and the survey of the leased territories with their aid (accompanied by contouring on the ground) is being undertaken by Lieut. H. Wace, R.E., with a small section (2nd Colonial Survey Section). Here, again, the work will prove of great interest. Existing maps of the leased territories are very poor and vary considerably in their ideas of position. The maps of the new edition are to be on a largish scale and will embody certain new ideas as to the use of air photographs.

The Corps has not confined its survey efforts, however, to warm latitudes. The Oxford Arctic expedition to Spitzbergen was accompanied this year by Lieut. J. R. T. Aldous, M.C., R.E., who was given leave by the War Office to proceed as a volunteer with a view to survey in North Eastland. His adventures will be told elsewhere, but he seems to have made gallant attempts in that inhospitable country to remove non-existent islands from, and to insert new bays and inlets upon, those most incomplete maps and charts which we now possess.

The Corps takes a certain part, too, in those international bodies which deal, under the International Council of Research, with geography and geodesy.

Colonel Sir Charles Close is the International Secretary of the Geographical Union, and the Chairman of the national and corresponding body. An international meeting at Brussels in April of this year included three of us as national delegates.

In September and October a meeting of the International Union of Geodesy and Geophysics was held in Madrid. Colonel H. G. Lyons, F.R.S., late R.E., is the International Secretary of this body. The geodesy section, with a large amount of business to transact, met earlier than the main body, and the British delegation included Colonel Sir Gerald

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Lenox-Conyngham, Colonel E. M. Jack and Colonel H. St. J. L. Winterbotham. We may also claim considerable interest in the fourth delegate, Mr. A. R. Hinks, Secretary of the Royal Geographical Society, as an Honorary Member of the Institution. No pleasanter place than Madrid could have been chosen for this gathering, nor could any reception have been more charming or more hospitable. All of us who took part owe a debt of gratitude to our Spanish friends of the Instituto Geografico and other geographical bodies whose kindness we shall not readily forget.

Much of the value of these international meetings lies in the broad outlook and interest which result from a discussion of schemes for international co-operation. Many such schemes were discussed under the effective presidencey of Mr. Bowie, of the Coast and Geodetic Survey, and one can only hope that some good may eventuate. Perhaps the most interesting general resolution was that choosing the Hayford Ellipsoid of 1909 as the one to be used for geodetic discussions of international importance. The difficulty of mutual comprehension on such a gathering is, however, obvious. English and French are the languages of official business, and it is a moot question which gets the worst mishandling. It would be a great help if no Englishman were allowed to speak in French or to translate his own words into French, and no Frenchman were allowed similar liberties with English.

H.St.J.L.W.

## *BOOKS.*

LES CHEMINS DE FER DE L'EST ET LA GUERRE DE 1914–18. By A. MARCHAND. (Berger-Levrault. Paris.) 1924. Price 40 francs.

THIS long book of 600 pages, with numerous plans, should prove of interest to all officers who are interested in what railways can do to further the work of their branch of the Service. Written by a high official of the Est Company, it gives the views of a technical railway man on mobilization schemes, plans of concentration and strategic moves, and on systems for meeting the requirements of an army in the field and for the evacuation of sick and wounded. It is far from being a mere catalogue of trains run or tonnages carried; figures are given here and there, but mostly only as illustrations and to enable a comparison to be made between the same work at different periods of the war, or the relative burden thrown on the railway by different offensive or defensive actions. It is well arranged in sections and chapters, and a reference to the detailed table of contents at the end enables a reader to pick out the subjects in which he is more particularly interested. At the end of each chapter is a summary of the conclusions to be drawn from the experiences described.

The writer starts with the express intention of telling, if not the whole truth, at any rate nothing but the truth, and the book is exceedingly frank. Many of the senior railway staff officers, with

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whom the British came in contact, are mentioned by name or can readily be identified. In discussing different subjects the author does not hesitate to say in effect: In this case the system was wrong, but the staff officer in charge was a strong man and made it work; in that case the system was right, but the officer responsible for working it took a wrong view of his duties and it failed. The large part played by personality in war comes out time after time, and the author recognizes that not every senior civilian railway official possesses the strength of character and activity necessary to deal with the technical railway problems which arise suddenly during periods of intense military traffic.

The author takes various services of the French Army and shows how, by force of circumstances, their cherished regulations and meticulous accounting had to be abandoned. What, he asks, is the good of making up a supply train to the exact strength shown on an indent when it will be five days after the date of the indent when the rations reach the unit, or of what practical value in war time is a check made by passing every single wagon over a weighbridge at a regulating station as well as at the depôt at which it was loaded up? He lays down that, as a general rule, the worst enemies of systematic evacuation of wounded are the medical officers. He ascribes to the French Medical Officer two axioms: (1) ambulance trains are made for the wounded, not the wounded for ambulance trains, (2) the primary business of a medical officer is not to consider "the wounded" (in bulk), but the individual "patient." True as these axioms may be in theory, they are not practical propositions when applied to the transport of wounded by railway. It was impossible to provide enough ambulance trains to convey all the wounded immediately after a heavy engagement and even if they could have been provided no railway line could have carried that number of trains. The medical authorities must base their arrangements on the number of trains that can actually be run, not on the supposition that they can have an unlimited number whenever or wherever they like. It is impossible to provide a separate train for each patient; if transported by rail at all the wounded must be carried not as individuals, but in trainloads.

The author says little about British troops beyond that they required much more from the railway than French troops and that their railway discipline was far inferior. But from his own account elsewhere in the book of the behaviour of French troops it would appear that there can have been little to choose between the two nationalities. The author is extremely severe on the Americans, both as regards their discipline and the technical railway working of the lines and installations manned by them.

The author's considered opinion on the subject of military control, the opinion of a civilian railway expert who has seen railway working in an actual theatre of war, is very definite—far from being a hindrance to a railway, military control is its salvation; it has its disadvantages, but they arise not from the military organization but from the state of war.

The French railway with which the British came most into contact

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was the Nord, and, incidentally, the author points out a few of the differences in the practice of the two companies. The variations were due partly to different views held by the French Staff Officers at the head of the two systems, and partly to the reaction of British methods of supply on the railway by which British requirements were met. On the Est, the military traffic was almost entirely French. But the author's critical examination of the ideas on troop moves, and on the best methods for the supply of an army in the field with which the French started the war and the modifications which experience and the force of circumstances compelled them to make, suggest a host of comparisons and new ideas. The book deserves close study by movement control staff officers, technical railway officers and officers of Army Services.

A.M.H.

## LA DIVISION LEGERE AUTOMOBILE.

By Général BOULLAIRE. (Berger-Levrault. Paris.) 3 fr. 50c.

THIS little book is a reprint of a series of articles which appeared in the *Revue Militaire Française* in the spring of this year. It deals with the composition and the tactical handling of a light mechanicalized Division. The subject is dealt with in a really practical way, and all the machines or weapons referred to either exist at present, or require comparatively little alteration to render them suitable for the work required.

The whole question of the rapid movement of troops by mechanical transport has been receiving a certain amount of attention since the beginning of the Great War, and many practical experiments have been made, both in the theatre of operations, and under more peaceful conditions. Until quite recently these experiments have taken the form of the temporary mechanicalization and grouping of existing units. The first efforts towards the formation of a definite mechanicalized organization were made by the French in 1918, when a special Division of dismounted troops, carried in lorries, was formed for co-operation with the Cavalry Corps. It was unfortunate that shortage of effectives prevented this formation being tested out in the last phase of the Great War. An advance has been made in the permanent establishments of the French Army by the transformation of cavalry divisions into *Divisions Légères* composed of a mixture of cavalry with infantry and light artillery carried in lorries, armoured cars, etc.

The conquest of the Sahara by the Citroen Kegresse track vehicle is claimed by the author to mark a milestone in the evolution of mechanicalized warfare, and leads him on to consider the composition and action of a super-mobile force covering the movement of an army transported in motor vehicles. In recent experiments one of the chief difficulties experienced arose from the fact that the normal daily march of lorry columns exceeds the radius of action of cavalry and cyclists acting as a protective screen, even when the latter are working on such narrow frontages that no lateral movement is necessary to ensure the proper reconnaissance of the country. Under such conditions a cavalry

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Division might be expected to move each day 80 to 100 kilometres on a front of 10 kilometres. The lorry columns could move, if unrestricted, 150 to 200 kilometres a day.

The advanced guard to a corps of two divisions carried in mechanical transport and moving on parallel roads, some 10 kilometres apart, would have to operate at a minimum distance of 20 or 30 kilometres in advance and on a front of 20 to 25 kilometres. It should possess greater speed than the main columns and be able to move straight ahead across country in order to search all ground. The reconnoitring detachments of ground and air forces of this advanced guard should operate 20 to 25 kilometres ahead of the advanced guard.

To carry out its duties of reconnaissance the advanced guard would have to move by day, whereas in theory it would be safer, and lend more to surprise if the main lorry columns moved by night. This would lead to a dangerous isolation of the advanced guard, say 150 kilometres in advance of the main body, in the evening. It will, therefore, normally be necessary to move the main body by day in bounds of 40 to 60 kilometres, the end of each bound being chosen to allow of a change of direction if required. As the advanced guard is moving so far ahead, it will be necessary to provide the main body with troops for close protection and these are treated separately.

For a force of two Divisions, as considered, the author suggests an advanced guard of a *Division Légère Automobile*, organized as follows: The front to be covered demands a certain amount of decentralization; this can be attained by dividing the front screen between three mixed brigades, each acting on a frontage of about 10 kilometres. These brigades must be strong enough to brush aside unorganized resistance, especially that of independent automatic fire weapons. For reconnaissance purposes it is suggested that each Brigade should have a squadron of light flexible track armoured cars of about 15 h.p., bullet-proof, and capable of moving across country at a speed of about 10 or 12 kilometres per hour, or along roads at about 40 kilometres per hour. Of these a group of five would be required per kilometre of front or a total of about 40 per brigade. These armoured cars would be supported by *groupes de combat* of 8 or 10 infantrymen, each *groupe* carried in a light track lorry (*camionette*), rendered splinter-proof if possible. Of these infantry in *camionettes* there should be two or three battalions in each brigade. They would, in turn, be supported by a mixed group of mechanicalized artillery, consisting of two batteries of 75-mm., one of 105-mm. and one of 65-mm. guns (for close support), and a section of engineers carried in *camionettes*. Each brigade must have a considerable amount of wireless to allow of control on wide frontages and the transmission of information.

Under the hand of the advanced guard commander there would have to be a reserve of power to enable him to break down, on a narrow front, resistance which might hang up his leading brigades, and to enable him to cross minor obstacles. These troops would include:—

One or 2 battalions in *camionettes*; 1 battalion of light tanks; various forms of armoured cars or mobile machine-guns; 2 groups of mechanicalized artillery (light and medium); 1 company of

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engineers with M.T. park; 1 M.T. bridging train; Signals; Air Force; A.A. guns; medical, supply and transport units.

The close protective troops for the main body would be required to operate on the flanks and between the main columns. For the force under consideration the author suggests the following troops:—

One company in *camionettes*; 1 squadron of 40 cross-country armoured cars; 2 squadrons of cavalry.

He suggests that the work of the advanced guard would be of a similar nature to that now performed by the new *Divisions Légères*, that the personnel and material should be drawn from the latter, the chief alteration being the replacement of horses by armoured cars and *camionettes*.

The personnel for the close protective troops might be drawn from the existing Reconnaissance Detachments of line divisions and from the Corps Reconnaissance Groups. Till the supply of track vehicles becomes sufficient for the complete reorganization on the suggested lines, General Boullaire suggests that a start be made by converting cyclists units into infantry carried in *camionettes*, and the mechanicalization of the artillery.

He recognizes that the question of petrol supply is going to be a serious matter for France in war, unless she be allied to one of the powers who control a sufficient portion of the world's supply, but he looks hopefully into the future in this respect.

The book closes with an example of the move of such a mechanicalized force across the southern Somme area.

Whatever views may be held as to the soundness of the conclusions come to by the author, the book will give the student of the military art something very definite to think about. The distances and speeds spoken of in this study seem almost fantastic, but when one reflects that vehicles exist at the present time whose performances are quite up to the suggested standard, the vision is not so "Wellsian" as would appear at first sight.

The author insists that 50 per cent. of the mobility of a force depends on security, and on this assumption he builds up the necessity for these special protective forces. As the mobility, even of "track" vehicles, also depends on their power of crossing obstacles, the study of this type of warfare must appeal to all engineer officers, who may be called upon to demolish crossings over obstacles on a scale hitherto unthought of, and to repair those crossings at such a speed as will allow heavy vehicles to move each day the enormous distances aimed at in the war of the future.

R.P.P.-W.

## LA METHODE D'INSTRUCTION DANS LE CADRE D'UN COMBAT DE BATAILLON.

By Commandant THIÉRY. (Berger-Levrault.) Price 6 francs.

OF all our peace-time military activities probably the most important, as it is certainly the most fascinating, is the training for war of our

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subordinate leaders. It is a subject which calls for deep thought, based on wide experience, and one which merits unlimited discussion in which the practical commander, who has proved himself a successful trainer of troops, must always be allowed the last word.

M. le Commandant Thiéry is an infantry officer of great experience. He commanded a battalion with marked success during three years of war and was later employed with the French Mission in training the Polish army. That he was a successful trainer of troops is shown, not only by the test of battle, but by the fact that his method of training was adopted in the official Instructions issued in 1918 and that it has since been embodied in the French Infantry Training of 1920. His views therefore merit our closest attention.

But to print a method in the Regulations is one thing: to make that method part of the habitual mental equipment of the army is another. And Commandant Thiéry complains that not only has his method been misunderstood by the compilers of the Regulations, but that those paragraphs of the Regulations which embody it have escaped the attention of the army in general. He is one of those who recognize a *crise d'instruction* in the French infantry which, he tells us, is suffering from a loss of confidence in the value of purely infantry fighting in modern war and from the lack of a definite doctrine of training: as a result, he finds a tendency to minimum effort, an absence of definite teaching, monotony, routine and formalism. And it is in the hope of overcoming this crisis that he now explains in great detail the sections of the *Règlement Provisoire* which set forth his method of training.

Commandant Thiéry has found by experience that to allow section, platoon, and even company, leaders to frame their own tactical training schemes does not lead, as one might suppose, to the creation of initiative, but to a contrary result. He finds that they will, in general, take the line of least resistance and will avoid those operations of which their own knowledge is shaky. In particular, he finds that they will neglect that most important of all operations, the conduct of the actual infantry battle after the company has advanced from the starting line and has come to grips with the enemy. Moreover the independent training of small units produces a false and dangerous outlook; since the essence of success in battle is the close co-operation of all units and of all arms in fire and movement, and the junior leader has not the knowledge of the action of the larger formations required to frame an exercise which visualizes the action of other units and arms. It is on this experience that Commandant Thiéry bases his method.

To give the small unit, including the M.G. platoon, a definite aim, to supply this picture of co-operation and to force junior leaders to solve the difficult problems which it involves, all training, whether on the manœuvre ground or on the barrack square, should, he holds, be carried out in the framework of a battalion operation previously conducted (*dans le cadre d'un combat de bataillon*).

Suppose that the sections (we are using, for convenience, the nearest British equivalents to the French organization)—suppose that the sections have learnt to move, to open fire rapidly, to exploit this fire,

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and to rally: the tactical instruction of sections and platoons then proceeds as follows:

i. The battalion commander conducts a battalion operation designed particularly to emphasize, for example, fire and movement. His criticisms are directed mainly to the action and shortcomings of the platoons and sections in this sense.

ii. On the following day the battalion commander stages a demonstration, for company, platoon and section leaders, of the action of some of the more interesting platoons in the above operation, explaining the points of his criticism.

iii. Company commanders then carry out, as company operations, one or more of the company manœuvres involved in the battalion attack, criticizing their platoons and sections for fire and movement.

iv. On the action of the various platoons so exemplified the whole of the section and platoon training in fire and movement is carried out, not only on the manœuvre ground, but also in close and open order battle drill on the parade ground. Every movement and episode practised is explained to the men as being a repetition or practice of some movement or action involved in the battalion approach march or battle which all can now visualize.

v. Finally the company and battalion operations are repeated as a test of the progress made.

vi. Another battalion operation is then carried out to teach some further principle or form of warfare, to train company commanders, for example, to co-operate with the battalion M.G., or with tanks.

The smaller unit, in fact, sees itself always acting in co-operation with other units and arms: on these lines the whole of the tactical training in the battalion is carried out.

But le Comdt. Thiéry proposes to carry his system further. He finds that battalion and even brigade commanders are not sufficiently *au fait* with the action of the larger formations in co-operation with other arms to be able to frame their battalion exercises on sound lines. He finds, as we, too, surely have found in the past, that the Regulations, remarkable as they are for their comprehensiveness and almost prophetic foresight, are yet more remarkable for their failure to get under the skin and into the habits of mind of those for whom they are intended. Generalizations, principles and theories, are apparently not readily digestible, even by French officers whom we generally credit with an appetite for such things greater than our own. "Demonstration," for most people, must accompany and not follow "explanation"; and it is difficult not to sympathize with Commandant Thiéry when he proposes to substitute for 80 pages of generalization on the co-operation of all arms, with which the *Règlement Provisoire* opens, two or three examples of divisional operations illustrated on the map and to deal in much greater practical detail, and with illustrations, with the various types and phases of battle with which the battalion will have to deal as part of a larger formation.

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As in the battalion, divisional and brigade exercises should, he considers, be framed as a basis of brigade and battalion exercises; the operations and criticisms of one manœuvre season forming the framework of the battalion and brigade training of the following year.

Above all he insists at all times on the practice of co-operation: brigade training must invariably envisage the action of artillery: tanks and artillery should actually be present or should be represented by competent officers, and the effects of our own and of the enemy's fire must be shown by a system of coloured flags: in company training the action of the M.G. platoon must always be shown; while in platoon and section training the positions and movements of neighbouring units, based on the preliminary battalion and company exercises, must invariably be indicated by flags.

Such, as we understand it, is *la méthode d'instruction dans le cadre d'un combat de batallion* of M. le Commandant Thiéry by which he hopes to substitute real and live training for *laisser-faire* and formalism. The idea will appeal to many; and, whatever we may think of his proposals, we must remember this—that it is a method which he has himself employed with marked success. Designed to meet the needs of a short service army, the method should interest the engineer officer who is required by *Engineer Training* to give his unit a considerable "infantry" training in the minimum of time.

In addition to demonstrating his method, Commandant Thiéry's pamphlet gives us many interesting side-lights on the French doctrine of infantry fighting. It is written in a style less easy to read than is that of most French writers, while its vocabulary, being unfamiliar to your reviewer, should make it a useful study for those Staff College aspirants whose knowledge of the French language suffers from similar limitations.

L.V.B.

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## SIMPLIFIED ORGANIZATION AND ADMINISTRATION. (WITH DIAGRAMS).

By Captain R. H. D. Bolton, the Duke of Wellington's Regiment. (Gale & Polden.) 4s. 6d.

The preface of this book claims that it is intended to help those reading for the Staff College and Promotion Examinations, and also for Cadets at Woolwich and Sandhurst. There is a good deal in the book which is especially valuable to the latter class, and officers on first joining. It includes a great deal of elementary information which is often crowded out of more advanced manuals, such as examples of different types of correspondence, details of kit, hints on how to keep accounts, etc.

When, however, the author gets on to the more advanced organization and administration, required for the Staff College and Promotion Examinations, the information is rather sketchy and sometimes misleading. This is especially the case in many of the diagrams. In this connection may be mentioned the diagram of the 18-pounder Battery R.A., which would seem to show all the transport, including ammunition wagons, as being under battery headquarters and not in the sections;

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the diagram of an infantry battalion fails to show that there is one officer responsible to the C.O. as O.C. Headquarter Wing; the organization and employment of Field ambulances is not clear; the Staff diagrams are not at all clear and seem to indicate the "G" is above "A" and "Q."

The desire to illustrate by diagrams, though laudable, seems to have been rather overdone.

The author would have been better advised to limit his readers to one class, preferably the Cadet and Junior Officer. A combination of the minor detail required by this class and the explanation of higher organization required for later examinations do not combine well in one book of reasonable dimensions.

The book is well referenced to the *Regulations*, well printed, and provided with plenty of blank pages for notes.

R.P.P.-W.

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## OPTICAL MEASURING INSTRUMENTS: THEIR CONSTRUCTION, THEORY AND USE.

By L. C. MARTIN. (Blackie & Son, Ltd. IX, 265. With Index. 8vo.) Price 17s. 6d.

THIS book deals with the construction and use of those many measuring instruments which depend upon microscopes or telescopes, or both, for their accuracy. Such instruments are theodolites and sextants, levels, range-finders, spectrometers, refractometers, curvature-measuring instruments, photometers, polarimeters and others. The field is a large one, and, except instrument-makers and professors at technical colleges, there cannot be many who are obliged, or inclined, to study all the instruments described. For the soldier, theodolites, levels and range-finders are the instruments with which he is chiefly concerned; and, even with these, he is not greatly exercised about the theory of their construction; though it may be admitted that, if life were long enough, he should find time to study this also, as well as their practical use. What the soldier and geographer, or both combined, do want, is a handy work of reference for use when trouble occurs with the instruments with which they may be observing. Thus it might be useful, in a military surveying party, to possess a book which would give information as to the construction of theodolite telescopes and micrometer-microscopes; and those who deal with range-finders might welcome a clear exposition of the principles on which these instruments are made, the errors involved, and the technical details of construction.

The book under review does, to a certain extent, meet the requirements indicated. But it is certainly not a book for a beginner. In the first few pages we meet with a reference to "the Petzval condition" without any explanation as to what this is; we find also in the first few pages Huygenian and Ramsden eye-pieces mentioned, which, of course, every schoolboy ought to be familiar with, but which, as a fact, most of us feel a little uncertain about unless we have looked them up in some reference book. Then we have an "ordinary flint and crown objective," "the second nodal point" of a lens, "the Gauss condition," "doublet

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and triplet achromatic lenses," and many other specialist matters, all referred to casually without description or comment. The reviewer puts himself in the position of the observer, let us say, with a theodolite, untrained in optics or in the manufacture of instruments, who wants to find out how his instrument is made, what are its inherent defects, what he can expect from it, and, if things go wrong with telescope or microscope, how he can set them right. He will not easily find the answers in this book, although there is much good matter in it.

The chapters on levels and on range-finders are likely to be more intelligible to the military reader than some of the other chapters. The former has excellent investigation, by Major E. O. Henrici, of the collimation of the Zeiss level, and the latter contains some account of the stereoscopic principle, which has more and more to be reckoned with.

C.F.C.

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## APPLIED ELASTICITY.

By JOHN PRESCOTT, M.A., D.SC., Head of the Mathematics Department, College of Technology, Manchester. (Longmans, Green & Co.) Price 25s.

ALTHOUGH the theory of elasticity has received the attention of many eminent mathematicians, very few writers on mechanics devote more than a very little space to the subject.

The treatise by Dr. Prescott is essentially mathematical and not a manual for engineers, as its title might suggest, but the problems selected for discussion are entirely of practical interest, and this consideration has led, as explained in the Preface, to the adoption of the title " Applied " Elasticity.

The first three chapters are devoted to an analysis of stresses and strains, with a few applications.

I take here the opportunity of mentioning that in the past I have met engineers who seemed to regard " stress " and " strain " as synonymous. This is, of course, not so ; stress is a force, whilst strain, though caused by stress, is essentially a geometrical magnitude ; thus tension (stress) produces elongation (strain), and shearing stress produces shear (strain).

The six equations connecting the stresses (at a point) parallel to the axes of co-ordinates, and also the three shearing stresses about lines parallel to those axes, with the corresponding strains, have been known for more than 100 years, but as they are just as fundamental as the six equations of motion in dynamics or the six equations of equilibrium in statics, any treatise on elasticity must of necessity commence with establishing these equations.

Chapter IV is devoted to a discussion on the empirical basis of elasticity. With the contents of this chapter most officers are familiar more or less, as also with most of the results of Chapter V, which deals with the bending of beams under transverse forces.

Chapter VI is devoted to thin rods subjected to tension or thrust, and Chapter VII to the torsion of rods according to St. Venant's theory, which assumes that all elements of the bar which are of equal length are strained in the same way.

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Chapter VIII deals with the energy of a strained body, and explains the principle of minimum energy, which can be very usefully applied to obtain sufficiently approximate buckling loads, and the periods of normal oscillations, etc.

Chapters IX and X relate to the transverse, longitudinal and torsional vibrations of rods, and Chapters XI–XVIII inclusive, to the stresses in curved beams and in the walls of spheres and cylinders, also to the stretching and bending of plates and the vibrations of rotating discs. The last Chapter, No. XIX, has for its object the investigation of the alteration in form of elastic bodies when pressed together.

There are three Appendices relating to the solution of certain differential equations.

The first seven chapters, though not exactly elementary, are not difficult reading, a moderate knowledge of the calculus, differential equations and of analytical solid geometry being all that is necessary. The remaining chapters are more difficult, and to understand them a knowledge of partial differential equations is required.

In the problems discussed it is assumed that the bodies concerned are isotropic, that is to say, that their elastic properties are the same in all directions. This, I think, will be generally approved of, as the discussion of allotropic (non-isotropic) bodies would have made the book much more difficult reading without adding to its practical value.

Within the limits that he has set for himself, Dr. Prescott is to be congratulated on having very lucidly treated a somewhat difficult subject. The treatise is an admirable one and should stimulate the study of elasticity.

As, at the present time, questions in this subject seldom or never appear in the mathematical Honours papers of the Universities, there is little incentive for its study. A possible reason for its omission is that, owing to the limited number of soluble problems, the subject does not lend itself to mathematical acrobatics. This consideration also may have induced Dr. Prescott to follow the example of Dr. Love and omit practice examples.

J. M. WADE, *Lieut.-Colonel.*, B.Sc. LOND.

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## THE CIVIL ENGINEERS' COST BOOK.

By Colonel T. E. COLEMAN, O.B.E. (E. & F. N. Spon. 4th Edition. 1924.) 10s. 6d.

A FOURTH Edition of this useful book, which was first reviewed in 1912 in Vol. XVI of this Journal, has been published.

There are many alterations in the general arrangement and a large number of new items and prices have been included, thus bringing the book up to date, both as to modern methods in engineering practice, as well as to current costs of work, plant and machinery.

In the original book a brief description of a large number of works, actually carried out in various parts of the world, together with the cost of them, was given, and this information was useful for purposes of approximate estimating, as well as serving as a partial check to the

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various rates and prices given in the text. Only a few such items are included in the present edition and, as a considerable time must elapse before a sufficiency of similar examples of post-war works and their costs have been built up to serve as a guide to the estimator and, until the conditions of labour and cost of plant, materials, machinery and transport have become considerably more staple than is the case at present, great caution must be observed in applying the rates quoted generally to any specific scheme of any magnitude.

It is essentially a reference book for Civil, Mechanical, Municipal and Electrical Engineers in civil life and is a supplementary volume to the author's well-known general building price book, *Approximate Estimates*.

The rates and prices quoted are stated to be average current ones in England, which limits the usefulness of the book to the R.E. officer, but to those in this country, who may require to know the probable cost of plant and machinery, or, who may have to arrive at very rough estimates of cost for extensive services, it should prove very useful and, in addition, it permits of comparative costs of varying methods of construction being made.

Many of the prices for the same work vary considerably and, as no key to localities in which work may be performed at a quoted cost is given, the estimator, making use of the book, must exercise a considerable amount of his local knowledge of conditions in selecting suitable rates for application to his particular case.

The book is of a handy pocket size and contains, in addition to cost items, many general notes and useful data for all those who are engaged in the practice of engineering.

It is to be hoped that the author will include actual costs of executed works, as they become available, in future editions. S.J.T.

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## A RECORD OF THE BATTLES AND ENGAGEMENTS OF THE BRITISH ARMIES IN FRANCE AND FLANDERS, 1914–18.

By Captain E. A. JAMES, 48th (South Midland) Divisional Signals, T.A., with a Foreword by Lieut.-General Sir HUGH JEUDWINE, K.C.B., K.B.E. (Gale & Polden, Ltd.) Price 4s.

THIS book is a reproduction of articles which appeared in the *Journal of the Royal United Service Institution* in August and November, 1923, with certain corrections and additions and two admirable indexes, one of place names and one of formations. The author claims it to be an attempt to produce a record of Armies, Corps, Divisions and, in certain instances, of Infantry Brigades and Battalions engaged in these operations. As a book of reference it should prove of considerable value.

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## TALES OF TURKEY.

By Major E. W. C. SANDES, D.S.O., M.C., R.E. (John Murray, Albemarle Street, W.) Price 5s.

MAJOR SANDES has already gained golden opinions from the Press for his book entitled: *In Kut and Captivity with the Sixth Indian Division.*

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In this first book of his he gave a very full account of the campaign in Mesopotamia towards the close of 1915. In the present volume he gives his experiences as a prisoner of war for two and a half years in Anatolia. The result is a book full of good stories and characteristic anecdotes, not only of Turks, Armenians and Russians, but also of British soldiers.

Public attention has lately been focussed on Anatolia in consequence of the Turco-Greek War of 1921–22, the tragedy of Smyrna, and the deportation of more than a million Greeks from their homes in Asia Minor.

Major Sandes has been well advised to publish the reminiscences of his two-and-a-half years in Anatolia; for a better general idea of the character of this little-known country can be obtained from reading his entertaining little book than could be gained from the study of many Blue Books.

His professed object in writing the book is entertainment rather than information. "It may help," he suggests, "to pass some idle moments without much brain fatigue."

The following specimen story may be given as a sample of the rest. It describes a conversation the author had with a British prisoner-of-war employed by the Turks on railway work in the Taurus Mountains.

The Germans were so eager for the completion of their railway tunnels that they induced the Turks to employ most of the British prisoners from Kut on this work. The valleys in the mountains were malarial and the work was very hard, and thus arose the terrible conditions under which our rank and file laboured and died. But the dauntless spirit of the survivors could not be quelled by hardship and suffering. They retained their pride of race, and though prisoners and seemingly helpless, they did their utmost to hinder their enemies and help their friends, even at the risk of flogging, starvation, and death. Let me recount a conversation with a soldier from one of the prisoners' camps near a railway station in the mountains.

"Well, sir," said he, "it was like this. There was a dozen of us in my squad, and we was doin' shuntin' work, and what not, in the sidin's of a large railway-station. Old Achmed, our *onbashi* (Corporal) was a sleepy old bird, so we talked it over among ourselves, and, says I, 'Look here, boys, we may be something prisoners, weary Willies, down-and-outs, etc., etc., but what I says is, we can still do our bit to spoil the arrangements of the blarsted Huns if we set down to it straight.' So then we put our minds to it, and we didn't 'alf play old Harry."

"Glad to hear it," said I. "And what did you do?"

"Well, sir, we got some of that 'ere hemery powder from an Armenian fitter bloke, and a small fret-saw. Then we waited till some more of those b—— Austrian airyplanes come into our siding before goin' on to Jerusalem. And then I strolls quiet-like to the *onbashi*, and I says, 'Ullo, *Kai-makam* (lieutenant-colonel), *choke-ayee bukshee* cigarette?' holding out a handful. So he takes a few and smokes like billy-oh behind a wagon with me in front of him doin' the perlite and passin' the time of day.. Meanwhile, my mates was at it like sailors out for a 'oliday. They put a nice 'andful of hemery into every airyplane cylinder and sawed almost through every strut, but not quite. Oh no! Not quite. Lord! I would 'ave given somethin' to see those airyplanes take the air!"

And thus the survivors in the Taurus did their best for their country! I wish I could have done as much. Certain death would have been the lot of every man caught damaging the aeroplanes, and well they knew it. But the success of their work was shown later when General Allenby's armies were sweeping the enemy from Syria. A letter then fell into the hands of his troops, addressed from the Austrian

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Air Force Commander on the Syrian front to his immediate superiors. In that letter he complained bitterly of the state in which his aeroplanes reached him, and he added that hardly any were fit to fly. Well done, indeed, comrades of the Taurus!

B.R.W.

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## HELD BY THE BOLSHEVIKS: THE DIARY OF A BRITISH OFFICER IN RUSSIA, 1919–20.

By Major L. E. VINING, R.E., I.S.R. (St. Catherine's Press.) 10s. 6d.

MAJOR VINING joined the Railway Mission which was endeavouring to organize Admiral Kolchak's transport in Siberia in 1919, and became engulfed in his retreat, which Major Vining says "puts the famous Retreat from Moscow in the shade," and was eventually captured by the Reds, with his party of 14 officers and N.C.O.s. A reviewer writes that "his literary style is atrocious; and yet this book, in all its simplicity, and with all its defects, is one of the best that has been published about the collapse of the Russian Empire," but one reader, at least, considers the style of this Diary in excellent keeping with the tale of cheery fortitude and devotion, which carried the writer and his comrades through such appalling difficulties and helped them to lighten the burdens, if only for a time, of so many of their fellow victims of Bolshevik tyranny. The kindly reference to R.S.M. Walters, R.E., by twenty years the oldest of the party, is not the least touching paragraph in the book, while the confidences of "George" and his five brother British Bolsheviks, whom the party found in one of the Moscow prisons, are delightful. "I told George . . . that if he was now such a rampant anti-Bolshevik and Communist after only two months' treatment, how much more would he be useful to be let loose in England after twelve months' sojourn in Russia."

F.E.G.S.

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## OUTLINE HISTORY OF THE RUSSO-JAPANESE WAR, 1904, UP TO THE BATTLE OF LIAO-YANG.

WITH QUESTIONS AND NOTES FOR ANSWERS.

By P.W. (London. Sifton Praed and Co., Ltd., The Map House, 67, St. James' Street, S.W.1. 1924.) Price 4s. 6d.

THIS book comprises 96 pages with 8 maps. (The map shown as the frontispiece in the table of contents is actually inserted at the end of the book.) The book is very clearly written, compact with useful information, and gives an easily absorbed picture of the campaign as a whole. The maps are adequate, but would be more easily followed if they all opened clear of the text, like No. 8. No doubt publishing costs prevent this ideal. There are one or two misprints, obvious and therefore of no great import; for example, at the top of page 8, "six 2-gun Horse Batteries" should read "two 6-gun Horse Batteries."

The book should prove very useful to officers studying for examinations in this campaign, especially if the problems put forward at the end of each chapter are honestly worked out and compared afterwards with the notes at the end of the book. There are 64 of these problems,

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and the notes for answers comprise valuable tactical and strategical studies in outline. These notes also contain useful references to other works on the campaign which may be consulted when in search of further detail.

Apart from preparation for examination, this contribution to military history by P.W. will form a valuable addition to any military library.

P.N.

## *MAGAZINES.*

### *THE JOURNAL OF THE ROYAL ARTILLERY.*

With the October issue the *Journal of the Royal Artillery* has taken a new form: it has not only become a quarterly, but the shape and typography have been changed, so that, except for its grey cover, it now closely resembles the *Cavalry Journal*. Some of the best known writers of the Royal Regiment have united to mark the change and give it a good send-off by contributing articles. Sir Charles Callwell provides one, "On Writing for Publication"; Sir George MacMunn discourses on "The North-Western Frontier of India To-day"; Sir Edmund Ironside, on "Snow Campaigns," with a portrait of himself in arctic costume; Lieut.-Colonel Leslie writes, "The Services of the Royal Regiment of Artillery in the Peninsular War." There are the usual technical articles followed by two general ones on "The Subaltern in India" and "Soldiering and Sport in Nigeria." We miss the valuable reviews of foreign periodicals that have been a feature of the old monthly editions, but as regards contents, general get-up, illustrations, and legibility, the new Journal is a decided improvement on its predecessor and we wish it every success.

J.E.E.

### *REVUE MILITAIRE GÉNÉRALE.*

(*June*, 1924.) *Les "Engins d'Accompagnement."* By Commandant Biswang.—The object of this article is to present simply and clearly a problem now exercising the best brains in the military circles of all the powers. Instructors will here find a full description of the characteristics of the French "*engins d'accompagnement*" of their organization, and of the current doctrine as to their tactical employment, while staffs will obtain enlightenment on the present state of the question both in France and abroad, what can be expected now, and what may be hoped for in the future. After a few preliminary observations in regard to the predominant part played in war by infantry, to which all the other arms are, strictly speaking, auxiliary, the writer defines the term "*engin d'accompagnement*" as an instrument capable of coming into action instantaneously against any obstacle impeding the advance of the infantry, one that is of great mobility and capable of following infantry over all sorts of country, one that belongs exclusively to the infantry, and is organized to engage objectives comparatively close but strictly limited in extent—in fact, an infantry gun, as distinct from the artillery weapons. Chapter I describes the properties, good and bad, of the

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existing weapons: (*a*) the 37 mm. Q.F. gun, 1916 pattern; (*b*) the 81 mm. Stokes mortar, 1918 pattern. Chapter II collates from the various books of Regulations the present French doctrine in regard to the tactical employment of the weapons. (*To be continued.*)

*The Peninsular War.*—The continuation of the article by Commandant Grasset.—At the beginning of June, Marshal Bessières, from his headquarters at Burgos, issued orders for the reduction of Santander, but had to recall the columns on hearing of the outbreak at Valladolid, the capital of Old Castille. Torquemada resisted the French, and was pillaged and burnt as an example. Orders were then issued that peaceable inhabitants were to be spared, and Palencia was soon afterwards evacuated by the insurgents and occupied without pillage. The Emperor, from Bayonne, acting on out-of-date information, again attempted to intervene, but fortunately his orders were not received in time. Resistance at Cabezon was easily brushed aside, and the arrival of fugitives at Valladolid determined the departure of the insurgent elements. The city then declared for France and was occupied without further opposition. The various columns were now directed on Santander, which was occupied on 23rd after slight resistance entailing heavy losses to the Spaniards. A feature of all the operations was the ease with which, except for the state of the roads, the French columns moved about a rough and inhospitable country abounding in defiles, and with very little intercommunication. The Spaniards had yet to learn that crowds of badly armed and undisciplined levies, however patriotic, are no match for regular troops. (*To be continued.*)

*Coal a Power in Peace and War.*—Taking as his text certain remarks in Ludendorff's *Memories* that coal and iron are the bases of all industries, and the advantages accruing to Germany during the war owing to the possession, in addition to her own mines, of the iron mines of Longwy and Briey, and the coal mines of Belgium, Northern France and Poland, M. Pierre Bruneau dilates upon the subject in this article, more especially in regard to coal. His remarks deal with three periods, prior to 1914, during the war, and subsequent to the Treaty of Versailles—and if they are mainly truisms, they none the less present the facts clearly and concisely and furnish food for reflection.

*Military Chronicle of Economic Questions.* By Pierre Bruneau.—When discussing the general Army Organization Bill which was passed last March, the Chamber devoted great attention to the boundaries of the mobilization regions. These do not correspond with those of the economic regions, yet the G.O.C. has not only to supervise the administration of his troops, but becomes "the executive agent for industrial, agricultural, and economic mobilization, which entails strict and continuous supervision." It is to be hoped that the Act providing for the general mobilization of the nation for war will introduce the necessary modifications.

A short paragraph refers to the military, diplomatic and economic successes of the late General Peller.

*Books.* The following is among those reviewed:—

*Le Rôle du Haut Commandement au Point de Vue Economique de* 1914 *à* 1921. By Pierre Bruneau. (Berger-Levrault).—This book narrates

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what was known of economic questions in the French army prior to 1914, and examines the French and German war plans from the economic standpoint. One chapter is devoted to the economic offensive of the High Command from 1914 to 1918, and constitutes the outstanding feature of the work, which ought to be adopted for the course of political economy in the military schools. At the present moment, when Parliament is about to discuss the Bill for national organization for war, this book appears very opportunely.

(*July*, 1924.)—*The Peninsular War.*—The article by Commandant Grasset is continued, and describes the operations before Saragossa. Here the French received a decided check, in spite of the fact that at first the most was not made of the city's adaptability for defence. A plan of the city is attached, scale about 4½ inches to 1 mile. Many of the defenders had already suffered defeat during the French advance, but defeat does not demoralize the Spaniard. In a short time he is recounting his exploits, encouraging himself, and raising the enthusiasm of his audience.—(*To be continued.*)

*Les "Engins d'Accompagnement."*—The article by Commandant Biswang is continued. Chapter II, a digest of the French regulations on the subject is concluded, and ends with a long quotation from an article by Commandant Gérin in the *Revue d'Infanterie* for June, 1923, which throws a strong light on the recent conception of the *fire base* as the foundation for a battalion attack. Chapter III deals with organization and traces its evolution from 1917 to the present year, when the regimental section of *engins d'accompagnement* comprises two groups, one of three 37-mm. guns, and one of three mortars.

Chapter IV argues that, owing to the limitation of the existing weapons, the *engin* of the future must be the immediately accompanying field artillery gun, but even this is not ideal, because it does not fulfil the required condition of being absolutely and always at the disposal of the infantry. Chapter V discusses the measures now adopted or on trial in foreign countries—A, Japan; B, England.—(*To be continued.*)

*Autumn Manœuvres in the Rhône Valley.* By Capt. René Andriot.—These manœuvres were of considerable interest, enhanced by the fact that two entirely new French formations were in action. On one side was a half brigade of *chasseurs mitrailleurs*, formed to hold suitable sectors of the front with machine-guns and automatic rifles, so as to economize man-power for use elsewhere. Each battalion consists of four normal machine-gun companies, and it is calculated that the four companies, deployed side by side, each in the necessary depth, could hold four kilometres of front. On the other side was a squadron of twenty caterpillar cars, of the same type as those which recently crossed the Sahara, and capable of transporting fire units across country. The country is vividly described and is illustrated by a map, scale 1/320,000. The general and special ideas are given and commented upon, and, without entering into a detailed description of the manœuvres, which were influenced by the large amount of material allotted to both sides, the lessons to be derived are ably and clearly brought out. (Should be read in the original.)

*Military Chronicle of Economic Questions.*—This month M. Pierre

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Bruneau draws attention to the close intercourse now obtaining between Reserve Officers and their comrades on the active list, so much so that the former have representatives on a consultative committee in the War Ministry. This is the more commendable as many of them will constitute the connecting link with the civil population on national mobilization, and a "technical study group" has been formed in their "National Union" to collaborate in making preparation for the economic mobilization, in anti-gas measures for the protection of the civil population, and in other activities. This step should lead to *official* organizations being formed in each mobilization region, embracing specialists from every profession, to assist the Commandant in his general mobilization duties.

A. R. REYNOLDS.

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## *REVUE MILITAIRE SUISSE.*

(1924. *Nos. 7 to 9 inclusive.*)

M. JEAN FLEURIER'S article entitled *Une Légende. La faillite de la fortification permanente pendant la grande guerre,* is continued in Nos. 7 and 9; the position of Antwerp is discussed and a description given of its defences. It is pointed out that the history of Belgium since the date of the declaration of its independence revolves round Antwerp; it was by the capitulation of its citadel (Nov. 29, 1832), when the Dutch General Chassé surrendered to the French Army under Marshal Gérard, that the liberation of Belgium was completed. Further, the Belgian people are justly proud of the importance to which Antwerp has been raised by the perseverance of its sovereigns: Belgium, a country possessing practically no shipping of its own, has nevertheless the port second in importance in continental Europe. M. Fleurier enquires why it is that Antwerp, the commercial capital of Belgium, also became its military capital. The faith of the Belgian people can, he tells us, be summed up in the words "*Anvers reduit national, Anvers imprenable.*" For fifty years the Belgians nursed the idea that, in the event of the repudiation by the signatories of the Treaty of 1839 of their obligations thereunder, the Belgian Field Army could, as a final resort, take refuge behind the defences of Antwerp and hold out there against either France or Germany to await the "*intervention salvatrice*" of Great Britain. The military importance of Antwerp is attributable more particularly to historical, political and economic causes, and to military reasons to a far less extent. The place has, it is true, been frequently besieged, and in 1814 and 1832 held out for long periods against superior forces. Again, the saying of Napoleon I. that Antwerp was a loaded pistol aimed at the heart of England has been forgotten neither by the Belgian people nor by the British, and has tended to foster the idea that Antwerp occupied a strategic position of considerable value. The fact, however, is that at all times large quantities of goods, possessing immense value, are stored in the dock warehouses of the city, and, in these circumstances, it is but natural that those who have been responsible for the national defence should have sought to afford military protection to a centre of such vital importance to the prosperity

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of the country. The stages by which the defences of Antwerp have been developed are set out in the original article. M. Fleurier points out that since Napoleon's time great changes have taken place which affect the strategic position of Antwerp; for instance, the delta of the Scheldt is to-day separated politically from Antwerp, so that, as long as Holland remains neutral, no military intervention *via* the Lower Scheldt is likely to take place for the purpose of securing the safety of the citadel. Further, history teaches that under the altered circumstances of war, owing to the progress made in the armament of armies, serious dangers exist in converting a populous city or town into a "*place de guerre*," and particularly so where no preliminary measures are adopted for ensuring an early evacuation therefrom of the civil population on the outbreak of war. Antwerp was intended to play the multiple rôle of a base and of a pivot of manœuvre; however, the intention to pivot the Belgian Army on Antwerp would only have been justified had the defensive organization of Belgium been planned to meet such a situation as arose in the autumn of 1914; as a matter of fact, the defensive organization was seriously defective. Liége and Namur were merely "*points fortifiés*" and were unable to fulfil their "*rôle maximum*," owing to the circumstance that *forts d'arrêt* had not been provided to cover all the passages across the Meuse; a "*zone fortifiée*" should really have been provided along the eastern frontier of Belgium. Again, in its isolated position Antwerp also was nothing more than a "*point fortifié*." A serious mistake was made, M. Fleurier points out, when, in 1906, it was decreed, against the advice of Leopold II., to dismantle the works of Termonde. Had the latter place been retained as a fortified centre, and provided with detached forts, on the lines suggested by General Liénard in 1905, a fortified zone could readily have been created in the western area of Belgium on the outbreak of war, the existence of which would, in all probability, have prevented the Germans pushing on to the Belgian coast during the early days of the Great War. When the decision was taken on September 9th, 1914, to provide defence works at Termonde and to create a fortified zone, it was already too late to do anything effective. M. Fleurier's view is that, whereas the defences of Liége and Namur were obsolete, those of Antwerp were incomplete.

W.A.J.O'M.

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*MILITÄR WOCHENBLATT.*

*25th December*, 1923.—In this number appears a long and interesting criticism of the last book of General Buat on the *Strategy of Hindenburg and Ludendorff*, by General von Kuhl. After saying that there is nothing new in the book except its title, as the history of the operations in the West has already appeared some time since in a French military publication, in which Buat's appreciation of Hindenburg and Ludendorff was contained, the critic goes on to point out the necessity for contradicting Buat's assertions and opinions owing to the widespread influence abroad of French military literature.

The description of the operations in the East in the first years of the War is generally adequate, although it fails to give due prominence

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to the great exploits of Tannenberg and the battles of the Masurian lakes. " As the boldly-planned German flank attack in North Poland in November, 1914, did not result in the rolling up of the entire Russian front, and as it was not possible to reap in the grand style the benefit of the brilliant second Masurian battle, Buat speaks in each case of a check. Before the battle of Tannenberg, so he relates, an intercepted Russian wireless message on 24th August disclosed the whole secret of the Russian movements so completely to the German Army Commander that it became a simple matter to bring off a decisive operation." Von Kuhl says, with regard to this, that they did not succeed in deciphering the Russian wireless till after November, 1914, but, as a matter of fact, on the 25th August important orders of the Russian Army of the Narew and Niemen came into the hands of the German Commander, but they had no influence on his decision and plan of battle ; the merit of the bold leadership is in no way diminished ! The main thing was the determined carrying through of the decision once it had been taken, in spite of the serious crises which ensued during the course of the battle. " It wanted strong nerves to remain firm when the news arrived that the First Corps was beaten, or when the airmen reported the advance of a fresh enemy Army Corps from the south on Neidenburg against the rear of the 1st Army Corps."

The German plan of operation, according to Buat, rested in August, 1914, on the belief that Russia, in consequence of her slow mobilization, would only be ready to take a hand after the decision had been won in France. This is called an error, quite simply, by von Kuhl. " The German General Staff were fully aware before the War that the Russian mobilization and the concentration had been appreciably accelerated, and that so long a period did not remain available for the operations in the West. That General v. Prittwitz after the battle of Gumbinnen would withdraw behind the Weichsel was, according to Buat, quite according to Count Schlieffen's idea, who had always recommended such a decision at his operation exercises. But the General Staff in August, 1914, disregarded Schlieffen's teaching, and could not make the decision to relinquish a whole province to the enemy." Here again, says von Kuhl, Buat is in error. Count Schlieffen was certainly of the conviction that in certain circumstances a province must be sacrificed in order to concentrate superior forces at the decisive point. But in the foregoing case for the German leader everything depended on maintaining himself as long as possible in advance of the Weichsel, so that time might be gained in the West to bring about the decision. If the Russians were at an early date to overcome the obstacle of the Weichsel and march on Berlin, then the War was in all probability lost. For that reason Count Schlieffen on the contrary always taught at Staff rides and War games that the strategic defence of East Prussia must be effected by offensive action, utilizing interior lines against the Narew and Niemen armies, which were separated by the Masurian lakes. Retreat behind the Weichsel was only considered as a last resort at the very last possible moment. " One would also thereby have left the Austrians to their fate."

After a reference to Buat's treatment of the difference of opinion

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between Falkenhayn, on the one side, and Hindenburg and Ludendorff, on the other, concerning the 1915 operations, von Kuhl comes to what he calls the centre of gravity of Buat's efforts, his severe criticism of the German offensive in 1918. The first error that Buat finds lies in the application of a new strategical method. Earlier in the war Hindenburg and Ludendorff had always aimed at outflanking both wings of the enemy, and had reproached Falkenhayn for always attacking straight to the front like a battering-ram, as on the Yser and at Verdun. Since 1917 Hindenburg and Ludendorff themselves seem to have adopted this method. The offensive in Italy in October, 1917, for instance, and especially the attack at Riga, were trial runs of the 1918 strategy. To this von Kuhl replies that it is perfectly well known that the difference between Hindenburg–Ludendorff and Falkenhayn was of quite another kind. Falkenhayn was in no way a professor of the massed attack as distinct from the outflanking movement. "The attack at Ypres was meant precisely to effect the outflanking of the enemy's north wing, and the place chosen for the break-through at Gorlice exactly conformed to the whole situation. The difference lay far more in the fact that Falkenhayn did not consider that a final decision could be gained with the forces available, and therefore went in for a careful husbanding of those forces, whereas Ludendorff strove for a decisive victory. How it was to be obtained, depended on the situation." In the spring of 1918, opposite an enemy front stretching from the sea to Switzerland, there was no room for a "Cannæ" as at Tannenberg, and so there was no alternative but the break-through.

Buat, too, has no other solution, but is of a different opinion as to the way in which this attack should have been carried out. Two methods were open to Ludendorff: either he must use up all the enemy's reserves by a succession of partial attacks rapidly following each other, in order then to break through the enemy position by a powerful attack and so bring about the complete collapse of the opponent, or he must concentrate everything on a single blow which would have so rapid a success that the enemy's reserves could not be brought up in time. The German leaders decided on the latter solution; this was their first mistake. A string of instances is then given to show that in every case the enemy reserves arrived in time to bar the way to the exhausted attackers. "The strength of a front consists not in the fortification of the position and on its garrison, but on the number and the value of the available reserves and on the possibility of getting them quickly into position." This possibility was greater in France than in Russia on account of the extensive railway communications and the vast transport material in the former.

That Germany was not in a position to exhaust the enemy's reserves by a succession of local attacks, however desirable that might be, is overlooked by General Buat. "Also he does not relate that our March offensive, according to French and English authoritative opinions, would have led to a complete break-through on the existing gap of a width of 15 km., in which there was not a single soldier, if only some German cavalry divisions had been at hand."

Consequently in the given circumstances German G.H.Q. was

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thoroughly justified in resolving on a decisive attack on 21st March, 1918. Buat disagrees with the choice of the point attacked, as the offensive led them on into the devastated area of the "Siegfried" position and of the battle of the Somme. The line of attack Arras–Abbeville suggested by Buat instead of that actually followed "was seriously considered by our headquarters, but rejected, because the attack on both sides of Arras was found to be tactically too difficult. For the limitation of the front of attack it was necessary to find a natural support for one flank. Such a support could be formed by the Somme for the offensive as actually carried out, whereas in an operation directed on Arras–Abbeville there was no possibility of this."

Von Kuhl admits that the German attack in May between Soissons and Rheims, the objective of which was originally only up to the Aisne and Vesle, by its astonishing success led right beyond these and up to the Marne, and that thereby the 7th Army found itself in an untenable position at the end of the battle. But he disagrees with Buat's assertion that German G.H.Q. had striven for a break-through on the Aisne. "The attack aimed only at a diversion. Before the decisive offensive in Flanders could be begun, the strong reserves up there must be drawn off in another direction." But the attack on the Aisne produced a brilliant victory over an enemy completely taken by surprise, so the advantage of the situation was utilized to the full to get the most possible from this success. The effort to widen the gap to right and left did not succeed, and the situation resulted in a salient up to the Marne, dangerously exposed on both flanks. To free themselves from this situation, the German G.H.Q. began, as Buat says, a fresh blunder, the attack on 15th July. The July attack on both sides of Rheims arose actually from the above forced situation. "Before the position of the 7th Army was improved, they dared not launch the attack planned against the English in Flanders."

The attack on the 15th July had a definite limited objective. Rheims was to be outflanked on both sides, and "pinched out." Von Kuhl says that Buat errs when he asserts that a decisive break-through was intended, and paints a completely imaginary picture of the German intentions.

After the failure of the July offensive and the success of the French counter-attack of the 18th July, there was a complete change in the military situation. "Buat now tries to prove that, in contradistinction to the faulty methods of attack of Hindenburg and Ludendorff, the Allies now applied a quite different and far more effective strategical method." A succession of attacks with limited objectives, following quickly one after the other, was to tire out the enemy till he had used up all his reserves. Then the day was to come when by one final great attack a decision would be won. The masses of heavy artillery and the thousands of tanks necessary for such a strategy were already on order since the beginning of 1917, and should be ready in the spring of 1918, at a time, moreover, when the intervention of the Americans was to be expected.

According to this principle they acted in the summer and autumn of 1918. "When, at the beginning of November, the Germans had only

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17 divisions left in reserve, while the Allies had 103, the moment had arrived for the great blow in Lorraine, which was planned for the 14th November." Marshal Foch's skill—this is what piques von Kuhl—had proved victorious over the German leadership. "Buat forgets that the German strength after four years of war was already exhausted in the summer of 1918. After the failure of the great offensive, on which all available forces and material were concentrated, the war was lost. The German reserves no longer needed to be used up, they were that already at the end of July." Von Kuhl then goes on to show, as he thinks, that the German commanders can well bear comparison with Foch, and finishes as follows: "The German offensive in 1918 was meant to bring about a decision, just because our resources would only suffice for a limited time, because the power of resistance of the central powers was coming to an end, and because the superiority of the enemy must go on increasing as time passed. That finally our forces did not suffice to bring about a decisive victory does not prove that the decision to assume the offensive was wrong."

E.G.W.

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*HEERESTECHNIK.*

(*August and September*, 1924, *Numbers.*)

IN the August and September numbers Major A. D. Jacobsen describes post-war activity in improving military gas methods. French, Polish and Checko-Slovakian units, schools, manufactories, etc., are described. An amusing paragraph describes Bolshevik methods of practising not only on animals, but on those condemned to death. A considerable number of casualties in the ranks and among airmen would seem to have partially avenged these victims. But such regrettable incidents are held to be compensated by the knowledge gained. Scandinavian, Belgian, Swiss and Italian measures are briefly alluded to. Our own field service regulations are quoted to show the measures we might take if gas warfare was forced upon us. Spain is described as starting experiments.

The Japanese gas bomb has a working area of two miles, and the gas hangs low on the ground. It is the American model which influences and shapes the policy of others in this matter, and American authors are quoted on their "super-gas" and on the value it is hoped to find in meeting oversea attack with gas bombs, etc. Germany's neighbours may be confidently expected to make extensive use of such methods. They will react on German tactics by :

(*a*) Causing casualties,
(*b*) Hindering movement and personal efficiency,
(*c*) Necessitating further stores and equipment.

As regards (*a*) the German mask is still efficient; regarding (*b*) several examples are quoted of the effect of gas masks on the speed of movement and on the efficiency of troops, and as regards (*c*) it is stated that a mass of additional gear had to be brought up in the Soissons-Château Thierry-Dormans area in consequence of new French gas methods. Finally

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the League of Nations is alluded to as being much perplexed in the matter, and the French are given the onus of having begun gas attacks, " Codlin's the friend—not Short."

A summary of the history of the fortified bridgeheads on the Rhine is given by Dr. Speich in a short article on the dismantling of German fortresses.

In writing of forecasting long spells of weather Dr. Kölser quotes Franz Bauer, who believes that by following Schuster he has made real progress. Dr. Kölser thinks that the methods of Vercelli are of more value, but he considers that it is still impossible to forecast the main features of the weather over long periods with any approach to scientific accuracy.

Buhle writes on the draft horse. The official regulations say little as to output of energy of a draft horse nor of the factors which determine it. Further numbers on this question follow.

Poland has been busy planning and organizing her girdle of fortresses and in constructing them under French advice. The various fortified lines and the individual fortresses and bridgeheads on them are described briefly in the August number.

Major Klingbeil is of the opinion that in modern war no Division will move in one column either by night or day. The following factors are against it :

1. The development of the air arm,
2. Long-range modern artillery, using survey methods,
3. The replacement of the horse by the motor,
4. Tanks,
5. The depth necessary to allow of the reinforcement or replacement of troops as quickly used up as they were in the war.

He argues, therefore, that marches will be organized in deployed and mixed detachments, using every road, however bad, and often directed across country. The duties of the pioneer are discussed as regards bridging, road repair, reconnaissance, etc., and he advocates an organization to allow of splitting up into as many small bodies as there may be detachments.

An interesting article on " the explosive air method " begins with explaining how the call on ordinary explosives during the War compelled industry to find some substitute. This substitute was liquid oxygen in conjunction with carbon—$C + O_2$ becoming $CO_2$ with such explosive force as to outdo all other explosives. Air is liquified and the oxygen, cleansed from all impurities, cased up in bottles on the thermostat model. This liquid oxygen is used to saturate carbon cartridges in which the hole for the fuze or detonator is previously made. (The cartridge is frozen hard, of course, so that no hole could then be bored in it.)

The cartridge is now ready, and remains explosive for some $\frac{1}{4}$ to $\frac{1}{2}$ hour. At the end of that period the oxygen has evaporated out and the cartridge is safe again. There are certain defects. No bottle can be designed to keep the oxygen from leaking out—and the leaking is worse, naturally, in transit. In fact, 25 kilometres appears to be the range to which the oxygen can be carried.

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On the other hand, the comparative ease of manufacture, safety in handling, and explosive energy, are, it is claimed, sufficiently great advantages to make it the explosive of industry of the future.

The 10th volume of *The Great War*, 1914–18, by M. Schwarte, *Organizations dealing with the moral life of the Army*, has now appeared. Included are chapters on the German military government in Belgium, Military Law, arrangements for German prisoners of war, religious work in the field, care of the injured, graves, morale, care of objects of art, and the High Command. The reason for the inclusion of all these apparently heterogeneous items is given, and the book warmly reviewed.

H.St.J.L.W.

*VOINA I MIR.*

*No.* 12.—The article on "Landing Operations and Coast Defence," by E. Dostovalov, which was begun in the tenth number, is continued. The author gives a brief description of the British landing operations in Gallipoli. He discusses the principles on which success in such operations must depend under the following heads: secrecy in preparation, unchallenged command of the sea and air, material resources, proximity of bases to the scene of operations, choice of landing places, time of landing, training and moral qualities of the troops and leaders, degree of previous technical preparation.

He thinks that in future landing operations special armoured motor-boats and amphibious tanks may be used, but that the air fleet will have a powerful influence on the success of the operations. The tasks of the Air Force of the attack will be:—

(1) Reconnaissance of the coast line; (2) active assistance during the landing by bombing and fire; (3) maintenance of aerial supremacy; (4) correction of artillery fire.

Owing to the difficulties of establishing aerial bases and the demand on air-craft for escorting transports, the advantages in aerial operations will naturally rest with the defence. He considers that amphibious tanks would be most useful in the initial stages of a landing for assisting the advanced guard to seize quickly important points. They would have to be towed to the proximity of the shore on rafts.

*No.* 13.—In the thirteenth number the article is continued. The author discusses the defence of the Russian coasts in the Baltic and Black Sea. After deciding the manner in which they were defended when the defence was assisted by a high-seas fleet, he discusses the defence under present conditions when the fleet is practically non-existent. The defence must depend on land forces, coast fortifications, aerial fleet, mine fields and the assistance of any naval vessels, including submarines, which may be constructed before the outbreak of war. He quotes Sir Percy Scott and other naval officers to show the immense value of the modern submarine. Having briefly outlined the coast defence systems of France and Italy, he proposes a scheme for the defence of the Black Sea coast under present conditions. In the absence of a high-seas fleet he reckons that six Army Corps and four fortified bases would be required, and dwells, at some length, on the questions of communications, roads and railways.

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*No.* 14.—In this number he completes his long article. He lays great stress on the value of the aerial fleet and on the advantages which the defence has in this respect, owing to the propinquity of its aerial base. He describes the advantages and disadvantages of artillery on railway mountings, and emphasizes the importance of properly organized mine defence, giving some account of the mine-fields in the North Sea. He then deals with the distribution and action of land forces and machine-guns; to illustrate the importance of the latter, he shows how the silencing of a machine-gun at Kum Kale greatly facilitated the French attack. He finally adds some remarks on the organization of command and responsibility. After reviewing the systems of different countries he comes to the conclusions: that countries with large land frontiers have been obliged to hand over coast defence to the Admiralty Department; that there must be officers of the air force and general staff of the Army on the naval coast defence staff; that when an extensive landing takes place, operations will have to be entrusted to an Army commander.

A.H.B.

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## *THE MILITARY ENGINEER*

### *July–August*, 1924.

*Super-power and its Public Relations.* By the Hon. Herbert W. Hoover.—The Secretary of Commerce reviews the progress of electrical generation and distribution. The perfection of high voltage, long-distance transmission and improvement in generating machinery now make possible the development of cheaper power from water sources further afield and from coal stations more favourably placed. The essence of super-power is inter-connection, which conveys the advantages of a better average load factor through pooling the effect of day and seasonal variations, and more security in power supply against strikes, whilst enabling stations to reduce the amount of reserve equipment. The development of super-power will depend primarily on the attitude of public bodies. Free flow of power across state boundaries is essential. The economic distribution of power rests to a large extent upon local territorial monopoly, which implies a measure of public regulation. The writer believes that the problem will find its solution in co-ordinated state regulation, with, perhaps, the assistance and co-operation of the federal government.

*Motor Transport in War.*—The Army has recently adopted the principle of pooling. The allotment of vehicles to units is limited to the immediate needs of the command to which they belong, the remainder being pooled in corps or larger units as required.

The writer discusses the effect of these changes and their possible influence on the future organization of M.T. Companies.

R.I.M.

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# *CORRESPONDENCE.*

## TIDES.

To the Editor, *R.E. Journal.*

SIR,

As you invite criticism of Mr. Louis Stromeyr's tidal theory, may I say that I agree with him that the tidal ellipsoids are due to distortion of the spheroid. But this is caused by the moon's attraction interfering with the equable pressure of terrestrial gravity and the wave is caused by the rapid shifting of the lines of pressure, due to rotation continually changing the face presented to the moon. This is the theory put forward by Moxly 26 years ago and has never been refuted.

The equilibrium theory was one of the first-fruits of Newton's theory of universal gravitation, and was only abandoned because, with the Earth rotating and the moon revolving, as in Nature, the currents assumed necessary to keep the vertices under the moon were found to be absolutely impossible (1,000 miles an hour along the Equator).

It also seemed contradicted by the tides of the Channel, which I have shown elsewhere* are largely (and when the moon is over the equator almost wholly) due to a *derived* wave from the Southern Ocean.

The dynamical theory which replaced it agreed better with the tides of our home waters, but was later found to be hopelessly inadequate to account for the tides of the Great Southern Ocean, where alone they have the chance of behaving as on the ideal world covered completely with a deep envelope of water, and for such *so-called* " anomalies " as single-day tides. But for want of a better, it remained the received theory of the world until Moxly showed that tidal force *could not produce current and must generate pressure* towards the point under the moon.

It is, I believe, universally admitted by mathematicians that it is the tangential component of tidal force that is the great tide raiser. Now whilst this varies according to distance from the vertex, it operates upon every particle in every line from the great circle of lowest water, 90° distant, to the vertex, and in every layer of water from the surface to the bottom of the ocean, so that the pressure is cumulative, or integrated in every line, just as it would be in a column of weights 6,000 miles high, where all is concentrated at the bottom, diminishing to zero at the top.

Now as all the lines of pressure meet under the moon there can be no relative motion, but a rise of level until the weight of water raised balances the pressure, when equilibrium results. But, as rotation changes the face presented to the moon, the whole system moves, producing the tidal wave by the shifting of the lines of differential pressure which originally produced the protuberance. As the wave has a length of 12,000 miles along the equator and a height of only

* *Moxly's Theory of the Tides*, by J. F. Ruthven. Published by J. D. Potter, Admiralty Chart Agent, 145, Minories, London; and *The Nautical Magazine*, November, 1919, to June, 1920.

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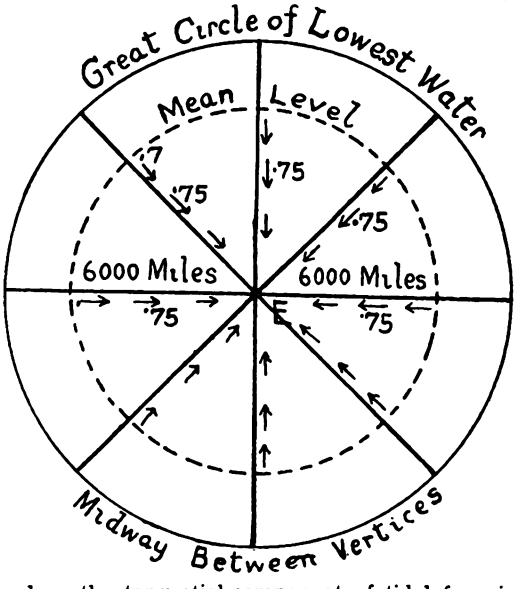
5 ft., it is, of course, invisible and the only indication of wave motion is the gentle rise and fall of 10 inches per hour, although the velocity is nearly 500 yards per second.




Sketch showing how the tangential component of tidal force is integrated from every point in the circle of lowest water through a distance of 6,000 miles to E, the spot under the moon (vertex).

If the moon's attraction was the only force in operation, the earth and moon would have crashed into each other centuries ago. The force that has prevented this catastrophe, and keeps them in their relative positions, is the centrifugal force of revolution. Whilst it exactly balances attraction the nature of the two forces is different. Centrifugal force has the same value for every particle of the earth, whilst attraction varies inversely as the square of the distance from the moon's centre. Thus the two forces are only equal on the centre particle of the earth, and on all particles which have this same distance from the moon. Attraction increases with diminishing distance, and builds up what is called an "overbalance" on the side of the earth facing the moon, raising the lunar tide which I have described. On the side remote from the moon attraction, gradually decreasing, allows centrifugal force to create in an exactly similar manner an "overbalance" which generates the anti-lunar tide.

With the moon over the equator, the crest running north and south through the 5 ft. vertex tapers away to mean level about the 55th parallels of latitude and thence to lowest water at the poles.

This theory is confirmed by observation of tides at islands in the Great Southern Ocean, such as Tristan D'Acunha, where at full and change the tidal crest is exactly where we place it, and as far removed as possible from the position assigned to it by the great French Astronomer Laplace, who, like Newton, was misled by the tides of our coasts.

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I have explained elsewhere,* how when the moon is away from the equator, it accounts for diurnal inequality, single-day tides, highest H.W. preceding lowest L.W. on one side of an ocean, and following it on the other, and many other so-called "inexplicable anomalies" that encumbered the tide tables up to less than twenty years ago. The explanations are generally so simple as to be obviously true, and much too numerous to be fortuitous coincidences.

Yours faithfully,

J. F. RUTHVEN,
*Ex-Commodore Orient Line.*
*(Moxly's Colleague).*

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## EAST PERSIA.

To the Editor, *R.E. Journal.*

SIR,

I note that, in the September number of the *Journal*, your reviewer of General Dickson's book, *East Persia*, comments on the fact that there "are no descriptions of the methods adopted for the crossing of ravines and streams."

I have not yet read General Dickson's book, nor should I in any case presume to answer the criticism, but I was myself engaged on the work of helping to build General Dickson's road, and I would suggest that the reason why no mention is made of "Inglis bridges, steel girders, or suspension work," is simply that no such things existed within 1,000 miles, nor could they have been brought to the site even if they had been available.

In the section on which I was engaged we had ravines; also we had streams of the usual violently intermittent character; and in a country where there was literally not enough timber to make a door frame, and only just sufficient camel transport to keep the troops and a large army of coolies decently fed, the only possible method of tackling road construction across ravines was to carry the road down to the river bed, treat a wash-out as an act of Providence, and repair it, first temporarily, and then semi-permanently, after the rains had stopped, by making up the road once more solid.

Latterly one did attempt to put in properly laid Irish bridges, and in some cases culverts, if one happened to find suitable large stones locally. But these were totally inadequate to cope with wash-outs, and one always had to keep a large gang of coolies ready for essential and hurried repair work.

I do, however, agree with the reviewer in the respect that a detailed account of the engineering difficulties overcome on the L. of C. would form a valuable addition to R.E. knowledge as such. Not enough has yet been written on this subject.

My own native Field Company—at one time the only Works unit on the Line—with true adaptability, coped with such problems as

* *Moxly's Theory of the Tides*, and *The Nautical Magazine*, November, 1919, to June, 1920.

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ranged between the carrying out of a water-to-water march of 48 miles in the blazing desert, and the providing of a blood-thirsty Havildar and two Sappers to lead the assault against the Bolsheviks.

I would pay a sincere tribute to General Dickson's driving energy in pushing his road through in such a marvellous manner.

I have the honour to be,
Your obedient servant,
A. PRAIN, *Captain, R.E.*

---

## THE DECISION TO DEFEND KUT.

To the Editor, *R.E. Journal.*

SIR,

As I had already written an article in the *Army Quarterly* of April, 1923, on the subject of Townshend's decision to hold Kut, I should not have taken notice of Major Sandes' article in the September number of the *Journal*, had it not been for a remark that he makes on p. 428: "This Shumran position was recommended by the Brig.-General R.E." I would like to ask Major Sandes whence he got this information, as I was the Brig.-General R.E. at the time, and I certainly did not recommend anything quite so insane as to hold the Shumran position, which was in every respect worse than that of the Es-Sin Banks; in fact, it would have been quite untenable.

Whether Major Sandes had read my article on Kut-el-Amarah, referred to above, or not, I do not know, but his defence of the decision to hold Kut only strengthens my conviction that it was a terrible error, both strategically and tactically. At the same time, it must be understood that it was the Commander of the Mesopotamia Expeditionary Force who was to blame rather than his subordinate, Major-General Townshend.

I trust that the fate of Kut may be an enduring warning to every British Commander not to shut up a Field Force in a fortress or defended place.

Yours faithfully,
*September 14th*, 1924. J. C. RIMINGTON, *Major-General.*

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The Editor, *R.E. Journal.*

Sir,

With reference to Major-General J. C. Rimington's letter regarding my article in the *R.E. Journal* of September, 1924, on the decision to defend Kut-el-Amarah, I trust that you will insert this reply to the criticisms expressed therein. When I wrote the article I had not had the privilege of reading General Rimington's article in the *Army Quarterly Magazine* of April, 1923, and, in fact, I was not aware that such an article had appeared. I hope that any views expressed by me in the *R.E. Journal* will not, therefore, be considered as being in deliberate opposition to those of General Rimington, whom I would have consulted if I had known the facts of the case.

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I admit that the alternative position, No. 1, above Kut, shown on page 427 of the September issue of the *R.E. Journal*, was incorrectly drawn, and that it appears that I was in error in asserting that that position, as shown, was recommended by the Brig.-General R.E. (General Rimington). The position should have been shown as extending also on to the left bank, and I offer my apologies to General Rimington for this mistake and for my remark that he had approved the right-bank position. I wrote on page 146 of my book, *In Kut and Captivity*, as follows: "But if our force had been an army corps, instead of four weak brigades, it seems that a better position could have been occupied upstream of the town, *and chiefly on the right bank*, where the force could have fortified and held a loop of the river, placing the Tigris between it and the enemy as a natural obstacle to his advance." That statement was seen by General Rimington, who wrote to me on the subject and did not question its accuracy at the time. As General Townshend did not have an army corps, he could not have held the No. 1 position on both banks. The same remark, however, applies to the No. 4 position at Es-Sin. But it seems that the possibilities of the No. 1 position, extending on both banks, were actually investigated, though rejected.

General Rimington alludes to my article as "a defence of the decision to hold Kut." I had no such intention in writing the article, and I have not expressed that attitude intentionally in the article. I would refer him to page 431 of the September issue, where I have stated in my article that military opinion now inclines to the idea that, whatever the difficulties and losses, Townshend should not have defended Kut, and to page 432, where I have remarked: "I think, however, that our force would have been capable of resuming the retreat as far as Ali-al-Ghubi or even Amarah after three days' rest at Kut." On the same page, also, I gave four reasons why, in my opinion, Townshend's force failed to fulfil its proper rôle by remaining in Kut. I think that these extracts dispose of the contention that I defend the decision to remain in Kut. But, though I agree with modern military opinion that Kut should not have been defended, I think that General Townshend was placed in a very unfortunate predicament, and I have tried, in my article, to examine impartially the factors which presumably induced him to remain in Kut, for they form an interesting study.

Yours faithfully,

E. W. C. SANDES, *Major, R.E.*

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## *ERRATA.*

*R.E. Journal, September*, 1924.

The Photograph opposite page 382 was by Messrs. R. B. Holmes & Co., Peshawar.

Page 396, line 14, *for* "supplied," *read* "sufficed."

,, 399, line 36, *for* "translations," *read* "transactions."

,, 400, line 41, *after* "cartography," *insert* "had."

,, 493, line 42, *for* "Military Engineering," *read* "Estimating and Construction."

,, 508, line 8, *for* "W.P.P.-W." *read* "R.P.P.-W."

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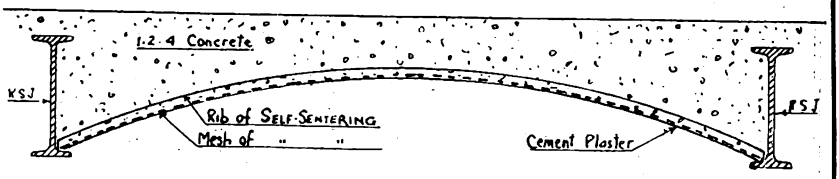


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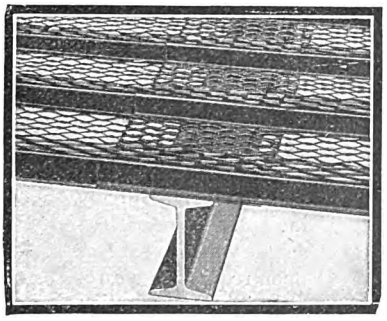

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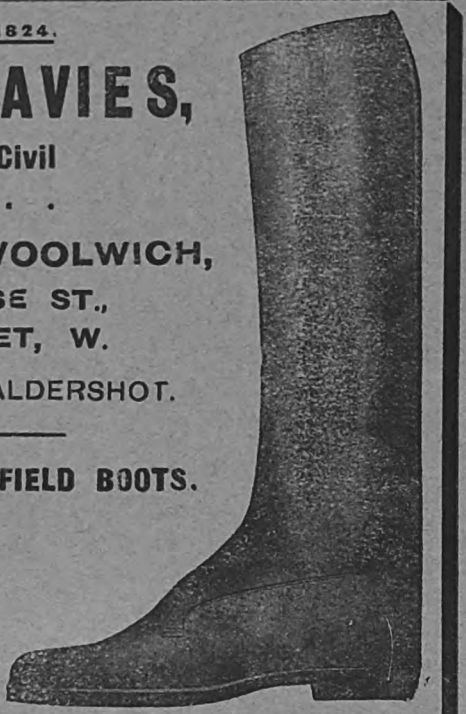

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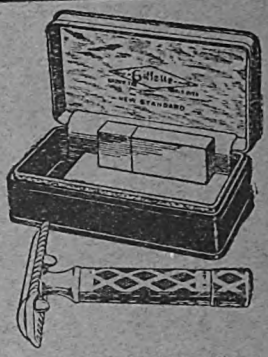


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